

*(Education - Program/Process Review)*

**BACKGROUND:** "There is no health without mental health". As our industry emerges from one of the most disruptive periods in our history it has never been more important for us to acknowledge this truth. Regulators play a key role in supporting industry to respond to this issue effectively. **OVERVIEW:** Acknowledgement of mental illness and asking for support with mental wellbeing continues to be associated with deeply embedded cultural stigma. Despite the aviation industry's awareness about human factors in performance and safety, we still need to navigate these barriers both for the people in our industry and for the systems with which it is regulated. "It is better to prevent than to treat". Several regulators are taking a best-practice preventive approach with the use of support groups and peer programs to facilitate the management of risk factors, and to prevent their evolution into established mental illness. Support groups and industry peer supporters can be a valuable layer in mental wellbeing and illness prevention and therapy. Their involvement could motivate licence holders to complete their treatments and return to flying duties. **DISCUSSION:** The future of aviation medical certification for mental health and wellbeing will ultimately be aligned with certification for other human conditions that impact function and performance such as fatigue. Compared with diseases like heart disease or diabetes, where there are well established and reliable diagnostic tests, mental wellbeing is difficult to quantify. However, we must strive to apply scientific method to the prevention, assessment and management of mental health issues. This panel will discuss: strategies to overcome barriers to diagnosis and declaration; approaches to working with workplace and industry for risk assessment; models for mental wellbeing, illness prevention and management in the aviation industry; and opportunities for research and scientific endeavours in aviation mental health. There remains a considerable body of work for regulators and industry to achieve the goal of accepting mental wellbeing as part of the normal human continuum. We can approach this task with optimism now that awareness of the issues has been firmly established in the aeromedical and aviation industry.

**Learning Objectives**

1. The audience will learn about the salutogenic approach to mental wellbeing, health and illness.
2. Participants will have greater awareness of how peer support workers and programs can support mental wellbeing in the aviation industry.
3. The audience will learn about approaches that regulators and airlines can use in prevention of mental illness as a part of better medical certification process.

### [17] EXPAND RISK ASSESSMENTS TO INCLUDE PSYCHOSOCIAL RISKS AND INCLUDE AN INTEGRATED HEALTH AND SAFETY PROGRAM AS PART OF SMS

David Schroeder

Retired, Oklahoma City, OK, United States

*(Education - Program/Process Review)*

**RATIONALE:** Data from the U.S., the UK, and other countries has consistently demonstrated that the most widespread hazard in the workplace is stress. Cooper (2000) provides a dynamic illustration of how psychosocial stressors in the workplace impact individual health, the organization and overall well-being. If unresolved, they can lead to poor health and lowered work performance. **DISCUSSION:** Cooper (2008) in commenting on the Black report indicates that this "requires a changed perception of health and well-being and a willingness from both employers and employees to invest resources and change behaviours." This presentation will demonstrate how psychosocial stressors in the workplace impact the safety culture in an organization by creating job strain and burnout which leads to lowered employee engagement, workplace compliance, and lowered performance. The literature clearly illustrates how the interaction of job demands and resources can produce burnout in pilots, flight attendants, and maintenance personnel and impact their performance and safety.

Recent integrated health and safety programs (Harvard's Safety Well, NASA's Integrated Employee Health Program and NIOSH's Total Worker Health program) provide sufficient evidence that health or well-being needs to be integrated with efforts to improve safety in the workplace. Those efforts include individual initiatives as well as organizational support for stress management, peer support groups and other interventions designed to support individuals and reduce the presence of psychosocial stressors in the workplace. **RECOMMENDATION:** The AsMA Aerospace Mental Health Work group has recommended that organizational Safety Management Systems (SMSs) have an integrated program that addresses both psychosocial risks as well as safety risks. In addition to existing efforts to reduce safety risks, efforts are needed to reduce the psychosocial risks and include the introduction of interventions (lifestyle, stress management, peer support) for individuals and the organization to improve employee health, safety, and wellbeing.

**Learning Objectives**

1. Be able to identify three of the more prominent psychosocial stressors within aviation workplaces.
2. Understand basic principles involved in an organization with an integrated health and safety program.

**MONDAY, MAY 22, 2023**

**Monday, 05/22/2023**  
**Grand Ballroom A-E**

**8:00 AM**

### OPENING CEREMONIES AND 68TH LOUIS H. BAUER LECTURE

**Chris Rocheleau, B.A., M.P.A.**

#### *"International Aviation & COVID-19: Response and Recovery"*

**Monday, 05/22/2023**  
**Grand Ballroom A-B-C**

**10:30 AM**

### [S-04]: PANEL: GOVERNMENTAL INTERAGENCY AND COMMERCIAL COLLABORATIVE APPROACH TO HUMAN SPACE FLIGHT MEDICAL SUPPORT

**Chair: Melissa Runge**

**PANEL OVERVIEW:** This panel presents a multi-agency effort to launch and recover the Space X Crew Dragon 4. The collaboration starts with training aerospace medicine experts who care for astronauts or lead rescue and recovery operations and results in synergistic capabilities between NASA, the Department of Defense (DoD) and SpaceX to accelerate our nation's human spaceflight program. US Space Command will review the DoD's role in Human Space Flight support, how we are organized, the planning process, and finally cover the role of the USSPACECOM Command Surgeon in medical operations. NASA looks at how crew surgeons prepared for the Commercial Crew mission with SpaceX and through emergency simulation, prepared their flight surgeons for a coordinated response supported by the DoD. A presentation by SpaceX describes the coordination required to work with and train DoD assets for rescue and internal resources used for nominal recovery. From 1st Air Force, Detachment 3, the DoD's Human Space Flight Support office, they describe the preparation and hands-on training required to ensure ready forces for Joint Service rescue operations and the DoD Surgeon's role to lead a collaboration for

definitive care. Finally, the last presentation informs the audience on the complexity of a crew surgeon's responsibility in any one of the Operations Centers supporting human space flight. The panel will showcase the medical capabilities and challenges present when multiple agencies collaborate to support human space flight operations.

## [18] US SPACE COMMAND'S ROLE IN HUMAN SPACE FLIGHT SUPPORT

Melissa Runge, Maiya Anderson

*U.S. Space Command, Colorado Springs, CO, United States*

*(Education - Program/Process Review)*

**BACKGROUND:** The DoD provides a range of capabilities to NASA as part of their crewed spaceflight programs, including rescue and recovery of astronauts, landing site support and medical operations. **OVERVIEW:** Understanding the planning process, as well as the responsibilities and complexities for DoD, NASA, and Commercial companies to successfully launch, land and recover crewed missions provides a context for what is required for safe and effective spaceflight operations. **DISCUSSION:** An understanding of each organization's structure, ensuring clearly defined processes and procedures, as well as established communication and collaboration norms is critical to operations. Through the lens of the Crew 4 mission, US Space Command will review the DoD's role in Human Space Flight support, how we are organized, the joint and interagency planning process, and the role of the USSPACECOM Command Surgeon in defining medical requirements and ensuring effective medical operations. As the human space flight mission and the number of mission partners grow, it is important to have clear and repeatable processes and collaboration methods to ensure safe and effective operations across multiple agencies in support of US Human Space Flight Programs.

### Learning Objectives

1. Understand the DOD Human Space Flight support mission and how the DOD is organized to execute this mission.
2. Explain the requirement and planning process for DOD Human Space Flight Support from a Combatant Command Perspective.
3. Identify the role and key tasks of the US Space Command medical office in supporting human space flight across multiple organizations.

## [19] NASA COMMERCIAL CREW PROGRAM AND MEDICAL OPERATIONAL CHALLENGES

Joseph Dervay

*NASA, Houston, TX, United States*

*(Education - Program/Process Review)*

**BACKGROUND:** NASA embarked on the Commercial Crew Program to launch astronauts into low-earth orbit from US soil and dock with the International Space Station (ISS). The eventual industry providers selected were SpaceX (SpX) and Boeing. These commercial transportation systems are vital to ensure crew availability on ISS for research and discovery. **OVERVIEW:** NASA/SpaceX Demo-2 (DM2) mission launched from the Kennedy Space Center in 2020 as the historic first crewed test-flight of the Crew Dragon spacecraft with two NASA Astronauts onboard. DM2 represented the first flight in 9-years from US soil since STS-135 in 2011. The 63-day mission ended with splashdown in the Gulf of Mexico, the first US water recovery in 45-years since Apollo-Soyuz. Validation of system hardware and operations allowed four-person crews to launch on subsequently missions (Crew-1, Crew-2, Crew-3, Crew-4, Crew-5 to date), which included International Partner crewmembers. **DISCUSSION:** A multitude of operational, training, medical, and technical issues needed to be addressed between NASA Medical Operations, the commercial provider SpaceX, and the Department of Defense. These included Flight rule development, occupant protection, pressurized suit testing, communication plans during mission phases, and emergency simulations for supporting Flight Surgeons and Biomedical Engineers. In providing crew experience with expected launch and entry G-force profile, Centrifuge

training was established. Preventive health measures via the Health Stabilization Program were especially vital during the global COVID-19 pandemic. Unique aspects arise for SpX Dragon parachute splashdown and shipboard recovery operations in the Atlantic Ocean and Gulf of Mexico. The new Commercial Crew Program is indeed a wonderfully challenging and exciting era for human spaceflight.

### Learning Objectives

1. Using the Crew 4 launch and landing as a model of success, describe the interagency collaborative approach required to address operational, training, medical and technical issues in preparation for the Commercial Crew Program.
2. Identify how flight surgeons used emergency simulations to prepare for contingency operations.

## [20] SPACEX MEDICAL RECOVERY OPERATIONS

Brandon Trapp, Jaime Mateus

*SpaceX, Hawthorne, CA, United States*

*(Education - Program/Process Review)*

**BACKGROUND:** This abstract is submitted as part of the USSPACECOM Command Surgeon's panel demonstrating the medical capabilities and challenges involved in human space flight support operations. SpaceX launched its first human spaceflight mission (Demo-2) as part of the NASA Commercial Crew Program in 2020. Since then, SpaceX has continued to launch both NASA and commercial astronaut missions. **OVERVIEW:** As part of bringing astronauts home safely from low Earth orbit, SpaceX provides medical capabilities for both nominal and contingency situations. These recovery missions include: Two ocean splashdown capabilities; Dragon recovery vessels specially designed for retrieval of the Dragon spacecraft and care of its crew; Coordination with NASA and its international partners, and/or commercial astronaut mission teams; Team design and training; Equipment preparation; Helicopter MEDEVAC from the vessel to either a nominal receiving center or nearby hospitals; and Pre-mission coordination with local trauma and hyperbaric centers. **DISCUSSION:** This presentation will give the audience the opportunity to see a SpaceX recovery mission from the viewpoint of the various entities involved including the returning crew, SpaceX medical and non-medical personnel, customer medical representatives, supporting medical facilities, medevac aircraft personnel, ship crew, and mission control operators. The audience will learn how these various governmental and non-governmental groups train independently and together to coordinate a successful mission. The audience will also learn the composition of the medical team including physicians, paramedics, and nurses and how they work together to form a cohesive team. Attention will also be paid to the pre-mission and mission-day logistics involved in putting this team in the right place at the right time to provide care to returning astronauts.

### Learning Objectives

1. Describe the key groups involved in a SpaceX medical recovery mission.
2. List the primary members comprising the joint medical recovery team and describe their roles and responsibilities.

## [21] THE ROLE OF DET 3 IN HUMAN SPACE FLIGHT SUPPORT

Sky (Jen) Wolf, Kristin Sylvia, Brent Maney

*Air Force Space Command Det 3, Patrick SFB, FL, United States*

*(Education - Program/Process Review)*

**BACKGROUND:** Det 3 is the office of primary responsibility for the Department of Defense's (DoD) Human Space Flight Support (HSFS) and the only unit within the DoD tasked to support contingency operations. Det 3 has been involved with HSFS since 1958 and currently consists of 50 personnel who specialize in global rescue, nominal recovery, retrieval/salvage, and medical response. **OVERVIEW:** HSFS, medical operations, includes support to 3 programs: Soyuz, Artemis,

and the Commercial Crew Program (CCP), encompassing 4 capsules: Russia's Soyuz, NASA's Orion, SpaceX's Dragon, and Boeing's Starliner.

**DISCUSSION:** Our case study will focus on Det 3's involvement with rescue forces in preparation for support of Crew 4's launch and landing where Det 3 coordinated the following processes: Integration of NASA's request for assistance (RFA) into a Program Requirements Document (PRD), which was subsequently translated into a request for forces (RFF) through the Joint Forces Global Force Management Program; Support of multilateral multidomain training/exercises with NASA, SpaceX, and DoD rescue forces; Procurement and allocation of medication and blood products; Medical oversight and instruction of the Pre-Hospital Space Medical Care Course (PHSMCC) during the Rescue Forces Qualification Course (RFQC) where rescue teams train on the intricacies of space medicine (including deconditioned astronauts, detection of hazardous chemicals to safe the capsule and procedures for extracting the crew); and Participation in the Joint Mission brief. Prior to launch and landing, Det 3 validated mission ready rescue forces in terms of blood products, medical equipment, medications, and crew health records. Finally, Det 3 conducted global command and control (C2) in the Support Operations Center (SOC) on the day of launch and day of landing which led to mission success.

#### Learning Objectives

1. Identify the key roles required to provide Global Rescue Response in support of the Crew-4 launch and landing.
2. Describe mission requirements for the Department of Defense to meet NASA's Request for Assistance in support of the Crew-4 launch and landing.

## [22] COMMAND AND CONTROL FOR HUMAN SPACE FLIGHT SUPPORT MEDICAL OPERATIONS

Benjamin Johansen<sup>1</sup>, Melissa Runge<sup>2</sup>

<sup>1</sup>NASA and USAF Reserves, Alexandria, VA, United States; <sup>2</sup>U.S. Air Force, Colorado Springs, CO, United States

#### (Education - Program/Process Review)

The coordination required to communicate across two governmental agencies, the Department of Defense (DoD) and National Aeronautics and Space Administration (NASA), and the civilian corporation SpaceX requires clear lines of communication and command and control. Systems in place to ensure success in contingency operations requires flight surgeons with the training to ensure operational safety, arrange transport to definitive medical care, lead patient care enroute, communicate across multiple agencies and the skillset to multitask and think critically. Command and Control is centered around a Joint SpaceX and NASA leadership team representing various disciplines including medical. The team operates from multiple control centers across the United States with the responsibility of maintaining situational awareness, facilitating flow of information, and managing risk in response to anomalies. Medical operations are further supported by flight surgeons and additional personnel representing NASA, DoD, and SpaceX with each position tasked to a specific element of the mission. Effective communication and well-defined roles and responsibilities are essential to team success. Each flight surgeon utilizes a variety of communication tools including voice loops, phone, messaging, and email with interfaces unique to each control center. Communication etiquette and jointly integrated tactics, techniques, and procedures allow the teams to function seamlessly through each mission phase. Using the NASA/SpaceX Crew 4 launch and landing as a model of success, this presentation will inform the audience on the complexity of a flight surgeon's responsibility in any one of the Operations Centers supporting human space flight.

#### Learning Objectives

1. Identify key tasks of flight surgeons who support human space flight across multiple organization's operations centers.
2. Explain the lines of communication which allow for full transparency in the event of patient rescue and transfer during human space flight operations.

Monday, 05/22/2023  
Grand Ballroom D-E

10:30 AM

## [S-05]: PANEL: CURRENT TRENDS IN VISION SCREENING AND SURGERY FOR PILOT SELECTION

Chair: Jonathan Ellis

**PANEL OVERVIEW:** All branches of service are experiencing challenges to fill pilot training slots with qualified applicants. Advances in surgical and vision screening techniques have allowed a way to safely open the aperture and recommend waiver for pilot training for applicants with conditions previously considered disqualifying. Despite the advances, the fundamental vision requirements of visual acuity, visual field, and stereopsis remain as key requirements for safety of flight in the aviation environment. Additionally, the Aeromedical Risk Analysis and Assessment Matrix (AMRAAM) has been developed, validated, and is currently being used to highlight the level of aeromedical risk. This panel will consist of four presentations from the Ophthalmology Branch of the Aeromedical Consult Service in the USAF School of Aerospace Medicine. The panelists will discuss advances in ocular coherence tomography (OCT) as a method to screen for pathologic conditions that can impact vision and safety in flight, discuss conditions that can be identified with this technology, and provide the calculated risk for those conditions with the AMRAAM. Next, innovative methods of using simple principles of optics will be showcased as a method to distinguish between possible visual field defects secondary to posterior staphyloma versus early glaucoma. Finally, a new classification of surgical techniques, minimally invasive strabismus surgery, will be presented. The indications, expected outcomes, and potential aeromedical impact for this strabismus surgery and how this surgical advancement can be leveraged to increase pilot applicants will be presented. Additionally, preliminary findings from both the Abnormal OCT and the Strabismus Surgery Management Groups will be discussed.

## [23] CURRENT TRENDS IN VISION SCREENING AND SURGERY FOR PILOT SELECTION PANEL

Jonathan Ellis

Aeromedical Consult Service, USAFSAM, Wright-Patterson AFB, OH, United States

#### (Education - Tutorial/Review)

**TOPIC:** Minimally invasive strabismus surgery (MISS) is a newer surgical technique designed to correct smaller amounts of strabismus. Previously, this level of strabismus was only correctable with prism glasses, which are not approved for use in USAF aircrew. Initially, the surgery was only performed by few and was not readily adopted. Now, it is performed much more commonly with more predictable results. The surgical techniques, indications, aeromedical risks, outcomes, and potential uses for the surgery in pilot applicants will be discussed. Preliminary results of the USAF Strabismus Surgery Management Group will be discussed to include outcomes of both traditional strabismus surgery and minimally invasive strabismus surgery. Finally, the Aeromedical Risk Analysis and Assessment Matrix (AMRAAM) will be used to highlight the overall aeromedical risk for pilot applicants who undergo MISS. **APPLICATION:** Correction of small angle strabismus to improve ocular alignment and stereopsis in pilot applicants. **RESOURCES:** 1. Wright KW. Mini-tenotomy Procedure to Correct Diplopia Associated with Small-Angle Strabismus. Trans Am Ophthalmol Soc. 2009;107:97-102. 2. Leenheer RS, Wright KW. Mini-plication to Treat Small-Angle Strabismus: A Minimally Invasive Procedure. J AAPOS. 2012;16:327-330. 3. Mojon DS. Minimally Invasive Strabismus Surgery for Horizontal Rectus Muscle Reoperations. Br J Ophthalmol. 2008 Dec;92(12):1648-1652. 4. Sanz PM, Sanchez, PG, Dominguez IB. Minimally Invasive Strabismus Surgery (MISS) Compared with the Fornix Approach in Pediatric Horizontal Strabismus Surgery. Strabismus. 2015;23(4):159-163. 5. Gupta P, Ddadeya S, Kamlesh, Bhambhawani V. Comparison of Minimally Invasive

Strabismus Surgery (MISS) and Conventional Strabismus Surgery Using the Limbal Approach. *J Pediatr Ophthalmol Strabismus*. 2017 Jul 1;54(4):208-215. 6. Pellanda N, Mojon DS. Combined Horizontal Rectus Muscle Minimally Invasive Strabismus Surgery for Exotropia. *Can J Ophthalmol*. 2010 Aug; 45(4):363-367.

#### Learning Objectives

1. The participant will be able to identify two types of Minimally Invasive Strabismus Surgeries.
2. The audience will learn about the indications, aeromedical risks, and outcomes for Minimally Invasive Strabismus Surgeries.
3. The audience will learn how to apply the new USAF Aeromedical Risk Analysis and Assessment Matrix to pilot applicants who have Minimally Invasive Strabismus Surgery.

### [24] OCT TECHNIQUES FOR INITIAL FLYING CLASS EXAMINATIONS

Austen Tanner

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

**INTRODUCTION:** The OCT and applicable operating techniques are essential for Initial Flying Class Examinations. **SPEAKER:** Austen Tanner, **OD TOPIC:** Ocular Coherence Tomography (OCT). OCT provides a quantifiable way to measure the health of the retina and optic nerve. Proper technique, scan selection and interpretation is essential to usage of the device. While the USAF does not have a medical standard for OCT test result values, the device's diagnostic capabilities are helpful in identifying several potentially disqualifying conditions. Overview of required USAF OCT testing for initial pilot applicants will be discussed alongside a case example that enumerates the abilities of the device. In addition the OCT Study Group will be introduced along with its application to USAF medical standards. **APPLICATION:** Ocular examination of pilot applicants and applicable standards. **RESOURCES:** 1. Carl Zeiss Meditec. (2015). Cirrus HD-OCT User Manual - Models 500, 5000. Jena, Germany. 2660021159751 Rev. A 2015-08. 2. Kabashi A, Dedushi K, Ymeri L, Ametxhekaj I, Shatri M. Colloid Cyst of the Third Ventricle: Case report and Literature Review. *Acta Inform Med*. 2020 Dec;28(4):283-286. 3. Palmer E, Gale J, Crowston JG, Wells AP. Optic Nerve Head Drusen: An Update. *Neuroophthalmology*. 2018 Apr 25;42(6):367-384. 4. Venkatesh R, Sinha S, Gangadharai D, Gadde SGK, Mohan A, Shetty R, Yadav NK. Retinal structural-vascular-functional relationship using optical coherence tomography and optical coherence tomography - angiography in myopia. *Eye Vis (Lond)*. 2019 Mar 7;6:8. 5. Zha Y, Zhuang J, Lin D, Feng W, Zheng H, Cai J. Evaluation of myopia on retinal nerve fiber layer thickness measured by Spectralis optical coherence tomography. *Exp Ther Med*. 2017 Sep;14(3):2716-2720.

#### Learning Objectives

1. Participants will be able to understand the basics of OCT operation in a clinical / occupational setting.
2. Participants will understand how specific OCT functions can be used to identify pathology.

### [25] IDENTIFICATION AND EVALUATION OF POSTERIOR STAPHYLOMAS BY OCT

Darrell Rouse

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

**TOPIC:** The ACS Ophthalmology Branch has completed Optical Coherence Tomography (OCT) testing on all USAF initial pilot applicants for the past few years. Two case examples will be used to demonstrate how the OCT may be used to quickly identify individuals who require further evaluation. More specifically, classic characteristics of OCT imaging

of posterior staphyloma will be illustrated and discussed. Finally, a novel visual field test technique will be showcased as an innovative approach to distinguish functional loss as a result of posterior staphylomas from other causes of visual field loss. **APPLICATION:** USAF initial pilot applicants.

#### Learning Objectives

1. The participant will be able to understand the use of a screening OCT for identification of a posterior staphyloma.
2. The participant will be able to understand the use of an OCT and VF for detailed evaluation of structural loss and functional vision loss related to a posterior staphyloma.

### [26] POSTERIOR STAPHYLOMA AS A CAUSE FOR VISUAL FIELD DEFECT IN PILOT APPLICANT

Michael Parsons

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial / Review)

**TOPIC:** A staphyloma is a circumscribed outpouching of the wall of the globe. Posterior staphyloma is considered a hallmark of pathologic myopia and are among one of the major causes of developing maculopathy. However, it can be present in non-myopic eyes. The most common form affects the macula, resulting in a very myopic prescription. This applicant had a rare form which occurs nasally and temporally, and in her case, spared the fovea. This subtype is called a Septal Staphyloma. Upon presentation to ACS, member continued to have a repeatable visual field defect OD within the central 20 degrees of fixation. She was also noted to have a nasal and peripheral staphyloma on OCT, but spared macula and fovea, making it difficult to detect. Using a novel approach and manipulating optics, we demonstrated that staphyloma was the cause of her visual field defect, and not of neurological etiology. Ultimately, the result of this was a persistent and repeatable visual field defect in the right eye within 20 degrees of central fixation, not qualified for aircrew duties. Applying the USAFSAM Aeromedical Consultation Service Medical Risk Assessment & Airworthiness Matrix (AMRAAM) tool, the member's visual field defect is always present, and therefore the likelihood is considered Continuous and the severity level is considered Critical. This results in an overall aeromedical risk score of (3), representing a High Risk level. There were no effective risk mitigation strategies that resolved this fixed visual field defect. **APPLICATION:** Recognize ocular anatomical structure abnormality and its resulting effect on optics, as cause for monocular visual field defect in a prospective UPT applicant. **RESOURCES:** 1. Curtin BJ: The Posterior Staphyloma of Pathologic Myopia. *Trans Am Ophthalmol Soc.*, vol. LXXV, 1977. 2. Von Graefe A: Zwei Sektionsbefunde bei Sclerotico-choroiditis posterior und Bemerkungen über diese Krankheit. *Albrecht von Graefes Arch Ophthalmol* 1:390-401, 1854. 3. Curtin BJ, Karlin DB: Axial length measurements and fundus changes of the myopic eye. Part 1. The posterior fundus. *Trans Am Ophthalmol Soc* 68:312-334, 1970.

#### Learning Objectives

1. The audience will learn about an anatomical abnormality of the globe called a staphyloma that can negatively impact visual performance.
2. Additionally, the audience will see how a basic application of optical principals can be used to explain how form can impact function.

**Monday, 05/22/2023**  
**Grand Chenier**

**10:30 AM**

### [S-06]: SLIDES: CLINICAL AEROSPACE NEUROLOGY

**Chair: Jim DeVoll**

**Co-Chair: Jeffrey Kinard**

## [27] CLINIC CASE: OPTIC NEUROMYELITIS IN A CIVIL AVIATOR

Patricia Barrientos<sup>1</sup>, Giancarlos Conde<sup>2</sup>, Alexandra Mejia<sup>1</sup>, Johana Giralddo<sup>1</sup>, Maria Angelita Salamanca<sup>1</sup>

<sup>1</sup>Aerocivil - Civil Aviation Authority of Colombia, Bogota, Colombia;

<sup>2</sup>Universidad de Cartagena, Corporacion Universitaria Rafael Nunez Grupo de Investigacion GINUMED, Cartagena, Colombia

(Education - Case Study)

**INTRODUCTION:** The optic neuromyelitis is an inflammatory and autoimmune illness of the central nervous system. It is characterized by attacks of optic neuritis and myelitis, being able to produce blindness, great neurological disability and even the short term death. Some years ago it was considered as a form of multiple sclerosis. It is currently considered a different disease, according to the clinical manifestations, imaging, serology and immunopathology profile. So far there is no effective treatment, the therapy is centered in the treatment of the acute attacks, the medical prevention of the complications and the rehabilitation. It is important to analyze the crew member possibilities under this condition to return to flight, managing the safety risk. **METHODS:** The case of a 27-year-old male aviator is presented here. He is reported based on his clinical findings which began with cervical pain associated with paresthesia in hands and lower limbs. Finally diagnosed and treated as a seronegative optic neuromyelitis spectrum disorders: antimog, medically controlled, autoimmune etiology. **RESULTS:** The case was reviewed and discussed at a medical board in order to decide a waiver possibilities. **DISCUSSION:** This is a review of an uncommon illness, considering aeromedical implications and the requirements for making decisions regarding about psychophysical fitness and the possibilities for giving a waiver to safety sensitive aeronautical personnel.

### Learning Objectives

1. The audience will be able to understand the aeromedical considerations to decide about risk and aviation safety when a crew member has this kind of neurological conditions.
2. The audience will be able to understand how the medical and scientific advances play the role to change the aeromedical considerations about fitting to fly.

## [28] CURRENT NEUROIMAGING TECHNIQUES TO MEASURE NEUROCOGNITIVE BRAIN ADAPTABILITY UNDER EXTREME ENVIRONMENTAL CONDITIONS

Sven-Erik Sönksen<sup>1</sup>, Christian Moritz<sup>1</sup>, Hans-Jürgen Noblé<sup>2</sup>, Sven Kühn<sup>3</sup>

<sup>1</sup>German Armed Forces Hospital Hamburg, Hamburg, Germany; <sup>2</sup>German Air Force Center of Aerospace Medicine, Cologne, Germany; <sup>3</sup>Federal Armed Forces Central Hospital Koblenz, Koblenz, Germany

(Education - Program/Process Review)

**BACKGROUND:** Extreme environmental conditions such as high altitudes and outer space, pose constant challenges to humans and coming aeronautical missions. The (patho-) physiological adaptation of the brain and neurocognitive strategies are both subject of current research. In addition to already established morphological imaging modalities such as magnetic resonance imaging (MRI), functional investigations continue to be in the foreground. Current and future functional neuroimaging techniques for neurocognitive assessment, learning, and expertise development will be presented and discussed. **OVERVIEW:** In particular, measurements under and after environmental exposure led to significant physiological findings. Currently, multiparametric MRI measurements are mainly concerned with gray and white matter morphology. These are complemented by measurements of cerebral blood flow (arterial spin labeling technique) and white matter microstructural integrity (diffusion tensor imaging, DTI). However, these techniques generally ignore the processing of cognitive activities. In the last decade, neuroimaging research has moved beyond this with the three main neuroimaging modalities: functional magnetic resonance imaging (fMRI), functional near-infrared

spectroscopy (NIRS), and electroencephalography (EC) enable connectivity analysis to reveal the dynamic properties of large brain networks.

**DISCUSSION:** Understanding the adaptive mechanisms as well as functional pathways of the brain are essential in pathophysiological studies under extreme environmental conditions. An attractive tool is offered by NIRS due to its hemodynamic measurement basis in the study of brain function. This can additionally be combined with structural, high-resolution 3D MRI data to produce complete functional maps. In addition, studies suggest that dynamic functional connectivity analysis may be a useful imaging biomarker to monitor changes in brain function. Ultimately, the combination of current modalities seems promising. Neuroimaging continues to have the potential to add to commonly used cognitive measurement tools to validate/challenge established theoretical assumptions and provide insight into pathophysiology.

### Learning Objectives

1. Understanding of modern functional neurological imaging techniques in pathophysiological investigations.
2. Possible combination of neuroimaging techniques in analysis under extreme environmental conditions.

## [29] INCIDENTAL FINDINGS ON MRI BRAIN IMAGING IN THE FIGHTER PILOT COHORT OF THE CANADIAN WHITE MATTER HYPERINTENSITY STUDY

Joan Saary<sup>1,4</sup>, Sharef Danho<sup>2</sup>, Joel Ramirez<sup>3</sup>, Bradley MacIntosh<sup>4</sup>, Fuqiang Gao<sup>3</sup>, Christopher Scott<sup>3</sup>, Shawn Rhind<sup>5</sup>, Oshin Vartanian<sup>5</sup>, Gary Gray<sup>1</sup>, Sandra Black<sup>3</sup>

<sup>1</sup>Canadian Forces Environmental Medicine Establishment, Toronto, ONT, Canada; <sup>2</sup>McMaster University, Hamilton, ONT, Canada; <sup>3</sup>Sunnybrook Research Institute, Toronto, ONT, Canada; <sup>4</sup>University of Toronto, Toronto, ONT, Canada; <sup>5</sup>DRDC, Toronto Research Centre, Toronto, ONT, Canada

(Original Research)

**INTRODUCTION:** Adding data to an international research effort to understand the clinical and occupational relevance of white matter hyperintensities (WMH) in aircrew, MRI brain imaging was undertaken on Royal Canadian Armed Forces (RCAF) fighter pilots to quantify the presence and amount of WMH in this population with unique occupational flight-related exposures (e.g. non-hypoxic hypobaria, G-forces). Invariably, in a given sample of MRI images, incidental findings are anticipated. This presentation will describe the incidental neuroanatomical findings found in a cohort of fighter pilots, compare them to incidental findings in other populations, and discuss aeromedical relevance. **METHODS:** After protocol ethical approval, 48 volunteer participants underwent brain imaging using a 3 Tesla (T) scanner as part of 2 days of research testing (additional results will be presented in future). Participants were assigned a unique study number to ensure confidentiality, also used as the identifier on the images. Nine imaging sequences were completed over the course of 2 hours for every participant. Incidental findings identified on structural MRI were reviewed by both a local Research Neuroradiologist and Neurologist, then flight surgeons to determine whether additional imaging would be required prior to a decision on aeromedical fitness, if needed. **RESULTS:** In total, brain imaging was completed on 48 participants (42 pilots, 6 high-altitude para-jumpers). Incidental neuroanatomical findings were detected in 4 individuals, all male fighter pilots (mean age 29.5, range 25-34) and included normal anatomical variants, developmental venous anomalies (DVAs), arachnoid cyst, and a non-specific nodule later deemed to be an imaging artifact. After review, one required additional imaging to further elaborate the findings, and none were ultimately deemed disqualifying. **DISCUSSION:** The rate and nature of incidental findings in this study are consistent with those expected using a 3T MRI. Given increasing availability of high-resolution MRI in clinical practice and research, identification of incidental findings is expected to grow. Many such findings have unclear medical significance particularly among aircrew, but some can be benign and managed expectantly. We present an approach to 4 incidental findings in fighter pilots; documenting such cases is important

to enable risk-based selection and surveillance decisions among unique trades in which sample sizes are small.

#### Learning Objectives

1. The audience will develop an understanding of common incidental findings found during brain MRI.
2. The audience will develop a framework for approaching incidental findings in healthy individuals that includes consideration of implications for use of screening MRIs in healthy Air Force applicants.

### [30] MULTIPLE SCLEROSIS IN CIVIL AVIATORS: CASE SERIES

Alexandra Mejia<sup>1</sup>, Giancarlo Conde<sup>2</sup>, Johana Giraldo<sup>1</sup>, Patricia Barrientos<sup>1</sup>, Maria Angelita Salamanca<sup>1</sup>

<sup>1</sup>Aerocivil - Civil Aviation Authority of Colombia, Bogota, Colombia; <sup>2</sup>Universidad de Cartagena, Corporacion Universitaria Rafael Nunez Grupo de Investigacion GINUMED, Cartagena, Colombia

#### (Education - Case Study)

**INTRODUCTION:** Multiple sclerosis (MS) is a CNS disease, with different phenotypic and variable course, demyelinating, chronic and autoimmune that progressively affects the individual, compromising their occupational and social role. The aim is to make known the atypical presentation in flight pilots and the considerations by aeronautical regulation in Colombia for patients with MS. **METHODS:** A case series is reported, three patients with MS, aged 33, 38 and 44 years respectively. 33-years-old male, manifestation of August 2019, with sensory and cervical symptoms, high lesion load, treated with alemtuzumab. 38-year-old female, begins in March 2020, with sensory symptoms in legs and genitals, high lesion load, with lesions in different CNS topographies, ocrelizumab is indicated with a favorable response and remission of symptoms. 44-years-old male, beginning 2001, with episodes of optic neuritis and outbreaks of central sensory and motor symptoms, required initial management with interferon B1 a, changed to fingolimod, due to persistence of new demyelinating plaques and new events, management of high lesion load is indicated with ocrelizumab. **RESULTS:** All the three cases were reviewed and discussed individually in medical boards, the aviation safety risk was taken into account to consider granting a waiver. **DISCUSSION:** MS is of unknown cause. In Colombia it is an orphan and disabling disease. The consideration could be to fly with operational limitations that allow aviation safety risk mitigation and periodic controls by neurologist which must be report complications.

#### Learning Objectives

1. The audience will be able to understand how the medical and scientific advances play the role to change the aeromedical considerations about fitting to fly.
2. The audience will be able to understand the aeromedical considerations to decide about risk and aviation safety when a crew member has this kind of neurological conditions.

### [31] RELEVANCE OF CLINICAL INCIDENTAL FINDINGS IN THE INITIAL ASSESSMENT SCREENING FOR PROSPECTIVE PILOTS

Hans-Juergen Noblé, Lennard Ostrop

Centre of Aerospace Medicine of the German Air Force, Köln, Germany

#### (Education - Case Study)

In our presentation, we talk about the significance of clinically incidental findings in the imaging screening process of young pilot candidates. In our department, we use a 3-T MRI as a high-end device, which covers the entire spectrum of MRI imaging with maximum performance. Thus, we combine expertise from the fields of military and civil aerospace medicine. Aeronautical fitness and flight safety are key to a successful pilot career. We present and discuss the two cases of a 19- and 20-year-old pilot candidate with a "syringomyelia" and a "dorsal thoracic arachnoid web." These two cases will be presented as examples because they represent a potential hazard to flight safety. Syringomyelia

describes a cavitary enlargement in the spinal cord, an accumulation of fluid due to the Dilation of the persistent central canal. In fact, it is very difficult to distinguish hydromyelia from syringomyelia, which is why the collective names hydrosyringomyelia or simply "syrinx" are often used to describe fluid accumulation in the spinal cord. The etiology and clinical presentation are variable, and little is known about the prevalence and clinical significance. Most of them are congenital idiopathic. Arachnoid web syndromes are very rare entities, with fewer than 10 cases reported in the neurosurgical literature. The main feature suggesting the diagnosis is a focal dorsal indentation and anterior displacement of the thoracic medulla by a thickened intradural extramedullary band of arachnoid tissue with compression of the spinal cord. The clinical presentation and prognosis are variable and depend on the extent of the mass effect on the spinal cord. Because of the limited number of reported cases, the incidence of this condition may be underestimated. Surgical lysis is potentially curative. The above cases demonstrate the importance of finding such lesions in the spinal cord, as they are clinically silent and usually congenital idiopathic time bombs with uncertain prognosis to recognize before starting a career pilot.

#### Learning Objectives

1. Spinal cord lesions can threaten flight safety. As a fact there are regularly incidental findings in clinically silent pilot candidates that definitely exclude their fitness to fly. Therefore it is essential to search for spinal cord lesions systematically.
2. High performed MRI-Imaging is the key to discover these lesions.
3. Spinal cord lesions are very variable in their clinical appearance.

### [32] PERIPHERAL BLOOD IMMUNO-INFLAMMATORY RESPONSE PROFILING IN MILITARY PILOTS AND AIRCREW – RESULTS FROM THE CANADIAN WHITE MATTER HYPERINTENSITY STUDY

Shawn Rhind<sup>1</sup>, Alex Di Battista<sup>1</sup>, Maria Shiu<sup>1</sup>, Oshin Vartanian<sup>1</sup>, Sandra Black<sup>2,3</sup>, Joel Ramirez<sup>2</sup>, Christopher Scott<sup>2</sup>, Miriam Palmer<sup>4</sup>, Gary Gray<sup>4</sup>, Joan Saary<sup>3,4</sup>

<sup>1</sup>DRDC, Toronto Research Centre, Toronto, ONT, Canada; <sup>2</sup>Sunnybrook Research Institute, Toronto, ONT, Canada; <sup>3</sup>University of Toronto, Toronto, ONT, Canada; <sup>4</sup>Canadian Forces Environmental Medicine Establishment, Toronto, ONT, Canada

#### (Original Research)

**INTRODUCTION:** Subcortical white matter hyperintensities (WMH) on T2-weighted magnetic resonance imaging scans are reported in military aviation populations with exposures to non-hypoxic hypobaria. Pilots with high WMH burdens showed poorer cognitive functioning compared to those with low burden. Pathobiological mechanisms underlying WMH lesions and related cognitive impairments could be linked to dysfunctional central and peripheral immuno-inflammatory activation with resultant microstructural white matter damage and neuronal injury. **METHODS:** This study compared immuno-inflammatory mediator profiles in a sample of male Royal Canadian Armed Forces (RCAF) pilots/aircrew (n=48; age:39y) with possible occupational exposure to hypobaria, with healthy unexposed CAF controls (n=27; age:33y). Unfractionated whole-blood samples underwent a 3-h culture with lipopolysaccharide (LPS) using TruCulture® (TC) assay system to assess *de novo* synthesis of soluble immune mediators. A 'Null' tube without immunogen served as unstimulated control. Circulating concentrations (pg/ml) of 50 inflammatory mediators [tumor necrosis factor alpha (TNF)-α, interleukins (IL)-1b, -1ra, -2, -4, -5, -6, -7, -8, -10, -11, -12p70, -13, -15, -17A, -18, -19, -22, -33; chemokines (CCLs)-2, -3, -4, -8, -16, -17, -18, -19, -20, (CXCLs)-5, -9, -10, -13; cytokine-receptors TNFR-1, -2, IL6R, C-reactive protein (CRP), myeloperoxidase (MPO), endothelial selectin (E-Selectin), vascular cell adhesion molecule (VCAM)-1, intercellular adhesion molecule (ICAM)-1, matrix metalloproteinase (MMP)-9] were quantified using Simple-Plex™ multianalyte cartridges on Ella® immunoassay platform. Usable values were defined as those within quantitation limits and displaying a CV<15% between duplicates. Group differences estimated by intercept-only linear

modelling. **RESULTS:** Pilots/aircrew had higher plasma levels of inflammatory mediators compared to controls, notably CCL2 (134.5 vs 124, 99% posterior probability [pp]) MPO ( $19.6 \times 10^3$  vs  $16.3 \times 10^3$ , 92% pp) and TNF- $\alpha$  (6.4 vs 5.8, 87.2% pp). Conversely, CRP ( $11.5 \times 10^5$  vs  $9.7 \times 10^5$ , 92% pp), and IL6R ( $5.1 \times 10^4$  vs  $4.8 \times 10^4$ , 87% pp) were lower in pilots. TC stimulation elicited greater inflammatory reactivity in pilots vs controls, as TNF- $\alpha$ , IL-6, IL-1 $\beta$ , CCL-2 CCL-20, CCL8, IL-8 were all higher in response to LPS-stimulation. **CONCLUSIONS:** The distinct profile of peripheral immuno-inflammatory biomarker expression and reactivity suggests a link between WMH and inflammatory activation.

#### Learning Objectives

1. The audience will learn about the methods used to evaluate for dysfunctional central and peripheral immuno-inflammatory activation.
2. The audience will learn about a distinct profile of peripheral immuno-inflammatory biomarker expression and reactivity suggesting a link between WMH and inflammatory activation in a sample of RCAF fighter pilots and jumpers.

**Monday, 05/22/2023**  
**Napoleon Ballroom C1-C2**

**10:30 AM**

### [S-07]: SLIDES: DO YOU REALLY WANT TO GO THAT HIGH? BAROTRAUMA & DCS

**Chair: William Buck Dodson**  
**Co-Chair: Bria Morse**

#### [33] DECOMPRESSION SICKNESS RISK ASSOCIATED WITH REPEAT ALTITUDE EXPOSURE

Vivienne Lee<sup>1</sup>, Desmond Connolly<sup>2</sup>, Timothy D'Oyly<sup>1</sup>, Thomas Smith<sup>2</sup>

<sup>1</sup>QinetiQ PLC, Farnborough, United Kingdom; <sup>2</sup>King's College London, London, United Kingdom

(Original Research)

**INTRODUCTION:** In 2017, two Royal Air Force parachute jump instructors experienced symptoms of severe decompression sickness (DCS) whilst undertaking despatcher duties at 25,000 ft. This prompted more conservative altitude exposure limitations and denitrogenation requirements for high altitude parachuting. Despatchers' risk of DCS is greater than aircrew and parachutists due to greater physical activity during cabin decompression, but absolute risk is uncertain due to lack of representative research. This study investigated the risk to despatchers following the new procedures and explored the potential for safely conducting repeat exposures in a single duty period. **METHOD:** Fifteen men aged 20 to 50 yr, without 'right-to-left' vascular shunts, underwent repeat altitude chamber decompression breathing 100% oxygen. Phase 1 comprised two ascents to 25,000 ft, 1 hr followed by 1.5 hr, each with 1 hr denitrogenation at 15,000 ft. In Phase 2, an identical initial ascent was followed by two 1.5 hr ascents to 22,000 ft with 30 min denitrogenation at 15,000 ft. All ascents were separated by 1 hr breathing air at ground level. Participants undertook activities representative of parachutist despatchers throughout. Cardiac echocardiography was undertaken every 15 mins to monitor venous gas emboli (VGE) loads. Participants diagnosed with DCS were recompressed and did not proceed to further ascents of that phase. **RESULTS:** Four cases of DCS were diagnosed from 29 initial ascents to 25,000 ft. One participant was diagnosed with DCS during subsequent ascent to 25,000 ft. No DCS occurred at 22,000 ft. During initial exposures of both phases, the majority of participants produced heavy VGE loads, from multiple limbs, within 30 mins. Participants tended to exhibit lighter, and later, VGE loads during subsequent exposures. Older participants (>40 yr) were more likely to experience symptoms and early heavy VGE loads. **CONCLUSIONS:** Exposure to 25,000 ft for 1 hr, with exercise, presents a risk of DCS. DCS is more likely during an initial ascent to 25,000 ft compared to a second ascent occurring after about an hour.

VGE loads tend to be reduced in subsequent ascents indicating carryover benefit of denitrogenation from prior ascents. Individuals over 40 yr are at greater risk of DCS.

#### Learning Objectives

1. The presentation will discuss the factors influencing risk of decompression sickness with repeated (same day) exposure to a provocative altitude. The audience should keep in mind the following: altitude; duration; exertion; denitrogenation; time spent breathing 100% oxygen; age; exposure interval.
2. The audience will be familiarised with the nature of venous gas emboli (VGE) loads with exertional decompression stress, emphasizing early onset, heavy and persistent bubble loads despite effective denitrogenation procedures.

#### [34] EARLY PATHOPHYSIOLOGICAL RESPONSES TO EXERTIONAL, NON-HYPOXIC, HYPOBARIC DECOMPRESSION STRESS

Desmond Connolly<sup>1</sup>, Leigh Madden<sup>2</sup>, Stephen Harridge<sup>3</sup>, Victoria Edwards<sup>1</sup>, Timothy D'Oyly<sup>1</sup>, Vivienne Lee<sup>1</sup>

<sup>1</sup>QinetiQ PLC, Farnborough, United Kingdom; <sup>2</sup>University of Hull, Hull, United Kingdom; <sup>3</sup>King's College London, London, United Kingdom

(Original Research)

**INTRODUCTION:** Consistent blood biomarkers of hypobaric decompression stress remain elusive. Laboratory investigation of decompression sickness (DCS) risk with repeat (same-day) exposure to 25,000 ft pressure altitude enabled investigation of pathophysiological responses to exertional decompression stress. **METHODS:** Fifteen healthy men, aged 20 to 50 yr, undertook two ascents to 25,000 ft, for 60 and 90 min, breathing 100% oxygen, each following an hour of denitrogenation. An hour separated the ascents, breathing air at 400 ft amsl. Venous blood was sampled pre-exposure (T0), after ascent two (T8) and next morning (T24). Besides whole blood hematology, endothelial microparticles (EMPs) were analyzed by flow cytometry, and selected proteins by enzyme-linked immunosorbent assay (ELISA). Targets included cytokines, markers of endothelial function, inflammation, coagulopathy, oxidative stress, brain insult, cortisol and creatine kinase. Blood/plasma volume shifts and diurnal variation were accounted for. **RESULTS:** Participants experienced heavy venous gas emboli (VGE) loads with three exposures curtailed due to limb bend DCS. Acute (T8) hematological effects on neutrophils (mean 72% increase), eosinophils (40% decrease), and monocytes (37% increase) normalized by T24. Mean five-fold elevation of interleukin-6 (IL-6) at T8 ( $P < 0.00001$ ) was pro-inflammatory (suppression of IL-10 and absent cortisol stress response). Complement system activation increased peptide C5a ( $P < 0.05$ ), and mean C-reactive protein (CRP) rose by 100% over baseline ( $P < 0.005$ ), supporting an acute phase response. Increased circulating total EMPs and tissue factor (TF) support endothelial dysfunction and oxidative stress influenced enzymatic and non-enzymatic markers. Glial fibrillary acidic protein (GFAP), a sensitive brain injury marker, increased 10% at T24 ( $P = 0.015$ ), and T8 serum levels of the neurotransmitter glutamate tended to rise ( $P = 0.078$ ). **DISCUSSION:** Pulmonary VGE loading appears to drive IL-6 release from neutrophils and/or endothelial cells, determining the magnitude of the acute phase response (CRP). Hematological responses and IL-6 normalized quickly but increased CRP, C5a, TF, total EMPs, GFAP and neutrophil gelatinase-associated lipocalin (indicating neutrophil activation) persisted, suggesting ongoing susceptibility to further decompression stress. The GFAP and glutamate data warrant concern; potential brain markers of decompression stress require further evaluation.

#### Learning Objectives

1. The presentation will outline the early blood biomarker responses to exertional decompression stress, emphasizing hematological, cytokine and acute phase (inflammatory) responses and suggesting a likely pulmonary basis for these in relation to oxidative stress and impact of venous gas emboli.

- The time course of recovery from the innate immune response to altitude decompression stress will be discussed in relation to potential increased risk of decompression sickness with provocative altitude exposures on successive days.

### [35] PHYSIOLOGICAL CEREBRAL ALTERATIONS UNDER HYPOBARIC/HYPOXIC EXPOSURE - A NEUROIMAGING EXCURSION

Sven Kühn<sup>1</sup>, Hans Jürgen Noblé<sup>2</sup>, Sven-Erik Kühn<sup>3</sup>

<sup>1</sup>Bundeswehr Central Hospital Koblenz, Koblenz, Germany; <sup>2</sup>German Air Force Centre of Aerospace Medicine, Cologne, Germany; <sup>3</sup>Bundeswehr Hospital Hamburg, Hamburg, Germany

(Education - Program/Process Review)

**BACKGROUND:** The physiological and pathophysiological adaptation of the brain at high altitude continue to be a matter of discussion. Understanding the mechanisms forms the crucial basis for preventive as well as therapeutic measures for affected groups such as high-altitude athletes and aeronautical professionals. This presentation will provide an overview of the current state of research and highlights the particular role of neuroimaging procedures. **OVERVIEW:** Hypoxia, and presumably to an unknown extent hypobaria, trigger a cascade of cerebrovascular mechanisms. Brain edema seems to play a key role. They are the result of significant vasodilation and are involved in the frequently accompanying headaches in high-altitude. Three different types of brain edema may develop, both overlapping and sequential: cytotoxic, ionic, and vasogenic. In addition, possible compression of smaller vessels of the white matter may be involved. Probably to varying degrees, there is a breakdown of the blood-brain barrier in later stages in some cases. At the latest with increasing intracranial pressures, the so-called glymphatic system is affected/will be impaired. Its exact role within this cascade remains unclear. There are already initial indicators of an involvement in the development of high-altitude cerebral edema. Accordingly, factors affecting the glymphatic system, such as sleep, are the focus of current research. Recent neuroimaging methods also contribute to the understanding of the background of this problem. **DISCUSSION:** Pathophysiological understanding of cerebral mechanisms under hypobaric and/or hypoxic exposure is essential. Physiological mechanisms that are not yet well understood, such as the glymphatic system and factors that influence it, could provide further insights. However, to fill the missing gaps in the cascade known so far, it is essential to fully exploit the possibilities of neuroimaging. This presentation is therefore of broad interest to clinicians and researchers who are interested in discussing the value and possibilities of neuroimaging in this particular field.

#### Learning Objectives

- The audience will learn about the physiological mechanisms of the brain at high altitude.
- The audience will be informed about the possibilities of neuroimaging to investigate these mechanisms.

### [36] PREVALENCE OF BAROTRAUMA DURING HYPOBARIC CHAMBER TRAINING AT THE COLOMBIAN AIR FORCE, 2010-2020

Diego Leonel Malpica Hincapié<sup>1</sup>, Laura Maria Pineda Jimenez<sup>2</sup>, Maria Alejandra Correa Guarín<sup>1</sup>, Sonia Jaimes<sup>1</sup>, Gustavo Adolfo Celis Ceballos<sup>1</sup>

<sup>1</sup>Colombian Air Force, Bogota, Colombia; <sup>2</sup>Universidad Nacional de Colombia, Bogota, Colombia

(Original Research)

**INTRODUCTION:** The hypobaric chamber is a simulator of the physical and physiological phenomena that occur due to the decrease in barometric pressure. The present study aimed to investigate the frequency and recurrence rates of barotrauma during hypobaric chamber training in the Colombian Air Force from 2010 to 2020.

**METHODS:** Retrospective observational study on aircrews undergoing hypobaric chamber training at the Directorate of Aerospace Medicine, who were diagnosed with middle ear barotrauma, oxygen aeritis, paranasal sinus barotrauma, alternobaric vertigo and aerocolia by the Otorhinolaryngology and Aerospace Medicine service. **RESULTS:** 6,745 crewmembers underwent hypobaric chamber training, 257 cases were included in the study due to symptoms of barotrauma, mostly men 195 (75.87%), ages from 19 to 47 yr (median 29 yr) and from the military 247 (96.10%). Middle ear barotrauma occurred most frequently 232 (90.27%), followed by oxygen aeritis 22 (8.56%). Regarding the grade of middle ear barotrauma, according to Teed's classification, the most frequent was grade 1 (77.15%), followed by grade 0 (19.39%), grade 3 (1.72%), grade 2 (0.86%), grade 4 (0.43%) and grade 5 (0.43%). The recurrence occurred in 42 events (16.34%), of which the majority were instructors. Total prevalence of barotrauma was 3.81% and, specifically, middle ear barotrauma prevalence was 3.43%. **DISCUSSION:** The prevalence of middle ear barotrauma during and after hypobaric chamber training is similar to what is reported in the literature, suggesting that a pre-chamber medical check including noninvasive methods such as questionnaires and physical examination, can help to identify subjects at risk.

#### Learning Objectives

- The participants will be able to understand the frequency of barotrauma in the hypobaric chamber training located at 8300 ft asl in both students and instructors and compare it to what is found on published scientific research.
- The audience will learn about the strategies for prevention of barotrauma among the aircrews when subjected to hypobaric chamber training in the Colombian Air Force.

### [37] HYPOBARIA-INDUCED CHRONIC BEHAVIORAL CHANGES IN A FERRET MODEL OF COMBINED UNDER-VEHICLE BLAST AND CORTICAL IMPACT-INDUCED TRAUMATIC BRAIN INJURY

Molly Goodfellow<sup>1</sup>, Boris Piskoun<sup>1</sup>, Amanda Hrdlick<sup>1</sup>, Julie Proctor<sup>1</sup>, Ulrich Leiste<sup>2</sup>, William Fourney<sup>2</sup>, Catriona Miller<sup>1</sup>, Gary Fiskum<sup>1</sup>

<sup>1</sup>University of Maryland School of Medicine, Baltimore, MD, United States;

<sup>2</sup>University of Maryland College Park, College Park, MD, United States

(Original Research)

**INTRODUCTION:** Warfighters targeted by improvised explosive devices may incur a unique traumatic brain injury (TBI) caused by under-vehicle blast (UVB) with or without an accompanying impact injury. Rodent studies have shown that aeromedical evacuation (AE)-relevant hypobaria exposure within 72 hr of TBI exacerbates injury. While rodent studies are useful, translating findings to improved patient outcomes is challenging, perhaps due to the rodent lissencephalic brain. Thus, a UVB + impact TBI model was developed in ferrets, who possess human-like gyrencephalic brains. **METHODS:** The protocol was approved by the University of Maryland, Baltimore and the U.S. Air Force Surgeon General's Office of Research Oversight and Compliance; research was performed in compliance with DODI 3216.1. Male ferrets were secured to a metal plate "vehicle," exposed to UVB via detonation of pentaerythritol tetranitrate, and given a controlled cortical impact (BCCI). Twenty-four hours post-injury, animals underwent a 6-hr simulated AE equivalent to ambient pressures at 8000 ft (hypobaria; HB) or sea level (normobaria; NB). Mood (play behavior) and motor function (ladder walk) were assessed monthly in BCCI and naïve animals. Additional mood/motor function (open field) and memory (novel object recognition and object location) tests were employed once at six months post-injury. **RESULTS:** Increased open field thigmotaxis by BCCI animals suggests anxiety-like behavior, particularly in those exposed to HB. Perirhinal cortex-dependent and, perhaps, hippocampus-dependent memory may be impaired following BCCI+HB but not BCCI+NB. No significant play behavior differences were noted though repeated exposures to mood assays may decrease sensitivity.

Gross motor impairments may persist; however, injured animals do show improvement over time. Changes in histopathological and neuroimaging measurements persist to at least six months following BCCI and may be further exacerbated by HB exposure. **DISCUSSION:** Preliminary results indicate that ferrets have potential as a gyrencephalic TBI model. This project is ongoing and will, eventually, compare outcomes from animals exposed to 0-5 simulated flights. Results will inform the creation of guidelines for the safe transport of TBI patients. The views expressed are those of the authors and do not reflect the official guidance or position of the United States Government, the DOD or of the USAF. Supported by USAF FA8650-20-2-6H20.

#### Learning Objectives

1. The audience will learn about the short and long-term effects of aeromedical evacuation-relevant hypobaria following traumatic brain injury.
2. The audience will learn about differences in brain anatomy between rats, ferrets, and humans and how these differences can affect outcomes following traumatic brain injury.

### [38] A RE-EVALUATION OF THE ACUTE EFFECTS OF WEIGHTLESSNESS

Jay Buckey<sup>1</sup>, Mimi Lan<sup>2</sup>

<sup>1</sup>Geisel School of Medicine at Dartmouth, Lebanon, NH, United States;

<sup>2</sup>Thayer School of Engineering at Dartmouth, Hanover, NH, United States

(Education - Tutorial/Review)

**INTRODUCTION:** A common analog for weightlessness is head-down tilt. The fluid shift produced when moving from supine to head-down tilt is believed to be similar to weightlessness where fluid moves headward from the loss of hydrostatic gradients. The move from supine to head-down tilt suppresses muscle sympathetic nerve activity (MSNA), reflecting a baroreflex-mediated response to the fluid shift. Peripheral resistance falls as a result of suppressed MSNA. We used numerical modeling and a literature review to determine if the same events occur with weightlessness. **METHODS:** The MSNA results of Iwase et al. were examined to assess the MSNA response to acute weightlessness during parabolic flight. A numerical model of the cardiovascular system that incorporates hydrostatic gradients and tissue weight effects was used to simulate possible primary effects of acute microgravity exposure on peripheral resistance. Multiple preflight body weights were simulated to study their impact. **RESULTS:** MSNA in the Iwase et al. study rose towards the end of the parabolas, rather than staying suppressed as happens with head down tilt. At the same time, blood pressure fell. Numerical modeling showed arterial and venous blood pressures falling in weightlessness because of reduced compressive forces on the vessels. Greater preflight body weight resulted in more dramatic decreases in inflight blood pressure. **DISCUSSION:** The acute effects of weightlessness and head-down tilt differ significantly. A possible explanation is that tissue weight likely effects the veins and arteries throughout the body by creating extravascular compression, and that the removal of this compression in weightlessness increases vascular compliance. This could produce a primary, weightlessness-induced reduction in peripheral resistance which remains reduced throughout a spaceflight and is associated with increased sympathetic nerve activity. Reductions in blood pressure seen with numerical modeling simulations support this explanation. This decreased peripheral resistance in weightlessness is not due to a baroreflex-mediated reduction in MSNA (similar to the cascade of events in head-down tilt). Instead, the reduced peripheral resistance may be a primary effect of weightlessness prompting by a baroreflex mediated increase in MSNA.

#### Learning Objectives

1. The audience will learn a different perspective on the acute effects of weightlessness.
2. The audience will learn about how the removal of tissue compressive forces is important in weightlessness.

Monday, 05/22/2023  
Napoleon Ballroom D1-D2

10:30 AM

### [S-08]: PANEL: CHANGES IN MEDICAL STANDARDS & SYSTEM CAPABILITIES DRIVEN BY NEW AEROSPACE TRANSPORTATION TECHNOLOGIES

Chair: Melchor Antunano

Co-Chair: Ryan Mayes

**PANEL OVERVIEW:** This is a panel session sponsored by the Aerospace Medicine Research Alignment and Collaboration (AMRAC) working group. The AMRAC was established to pursue R&D coordination and collaboration in aerospace medicine between the FAA, NASA, US Army, US Navy and USAF. In this panel, NASA will discuss advancing medical system design and risk-informed decision making for space exploration beyond low Earth orbit to promote human health and performance. The FAA will discuss the application of General Systems Performance Theory to quantitatively assess the adequacy of human performance given current health state when determining fitness for duty in current and emerging aerospace systems. The US Army will focus on the impact of the Army's future family of aircraft, "Future Vertical Lift," on Army aircrew performance, occupant protection, aeromedical standards, and system capabilities, based on the requirements driving the FVL acquisition program and anticipated available technologies in the 2030-2040 timeframe. The US Navy will focus on aeromedical and human performance challenges of new platforms in distributed maritime and expeditionary operations, including discussion of air crew safety and performance issues in F-35 B/C and patient movement in the new CMV-22 tiltrotor platform. The USAF will discuss future operations through two lenses: 1) The challenges of patient movement with decreased access and increased time and distance, and 2) Optimization and maintenance of human performance as operations evolve.

### [39] EFFECTS OF FUTURE ROTORCRAFT DESIGNS ON AVIATOR PERFORMANCE, AEROMEDICAL FITNESS STANDARDS, AND AVIATION MEDICINE

John Crowley

U.S. Army Aeromedical Research Lab, Fort Rucker, AL, United States

(Education - Program/Process Review)

**BACKGROUND:** The U.S. Army's Future Vertical Lift (FVL) program is developing a family of new aircraft with expanded mission and flight characteristics, featuring new technologies that will test the limits of human performance, and present new physical challenges to aircrew health and survival. The U.S. Army Aeromedical Research Laboratory (USAARL) is leading a comprehensive research program into the aeromedical challenges presented by the FVL family of aircraft. This presentation will highlight the platform and technology characteristics that are enhancing capability while urgently driving research leading to changes in selection criteria, training, and aviation operations. **OVERVIEW:** The expanded flight envelope of FVL aircraft will expose aircrew to hazards related to vibration and sustained acceleration that could affect future aircrew training and require aeromedical input to aircraft design specifications. Changes to the aircraft flight profile will demand redesign of aircraft crashworthiness systems critical to aircrew survival in the post-impact environment. Anticipated changes to mission duration and consequences of large-scale combat operations heighten concerns regarding acute and chronic aircrew fatigue. Ever-increasing complexity of evolving aircraft systems and tactics have raised concerns about aircrew workload that may exceed capabilities. The necessity of operating in a range of degraded visual environments (DVE) introduces new pilot-cueing technologies that will place new demands on aircrew senses and cognition. **DISCUSSION:** New fitness standards are already under development for FVL aircrew: 1) Visual displays with augmented/virtual

reality: Future displays featuring stereo imagery and/or symbology with overlaid environments require a relook at stereopsis requirements as well as research into susceptibility to, and countermeasures for, motion sickness variants (e.g., VR/AR/simulator sickness); 2) Spatial auditory displays: 3D (spatial) audio cues, while reducing workload, will require development of safe binaural hearing standards; and 3) Physiological monitoring: Real-time operator state monitoring systems, feeding into adaptive aircraft automation systems, will require a new look at waived medical conditions and pharmacology, as these may interfere with necessary state detection algorithms. Ongoing research is aimed at ensuring an optimal match between future aircraft platforms and the Army aviator of tomorrow.

#### Learning Objectives

1. The audience will learn about the aeromedical challenges of future military rotorcraft.
2. The participant will be able to discern the potential effects of future aviation platforms on human performance, protection, and medical fitness standards.

### [40] AEROSPACE MEDICINE IMPLICATIONS OF POTENTIAL FUTURE U.S. AIR FORCE OPERATIONS

Ryan Mayes<sup>1</sup>, Tamara Averett-Brauer<sup>2</sup>, Peter Baldwin<sup>3</sup>, David Burch<sup>2</sup>, Lidia Stana Ilcus<sup>4</sup>, Maximilian Lee<sup>1</sup>, Paul Nelson<sup>1</sup>, Clifford Otte<sup>2</sup>, Anthony Waldroup<sup>1</sup>, Amy Hicks<sup>1</sup>

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#### (Education - Program/Process Review)

**BACKGROUND:** As the United States Air Force (USAF) prepares for potential future conflicts, it has published several documents outlining what operations could look like in the near- and mid-future. In general, the USAF is preparing for potential peer or near-peer conflicts. Specifically, these plans address evolving concepts of operations in situations of denied access, loss of sanctuary, disrupted Command and Control and logistics, and adversary disregard for ethical constraints.

**OVERVIEW:** The USAF provides aeromedical support to both Air Force and Space Force and will need to account for future operations of both services. As operations evolve, aerospace medicine considerations will change accordingly; this presentation will discuss those implications through two primary lenses. The first perspective will describe the challenges of patient movement with decreased access to wounded troops and with dramatic increases in the time and distance needed to move those patients. The second perspective will explore the need to maximize readiness, ensure effective human systems integration, and the optimization and sustainment of human performance in future operations. **DISCUSSION:** Future operations will drive significant changes to aerospace medicine in the USAF. Decreased access to combat zones would likely impact the ability to stabilize or restore patients in the field, and would create challenges in preparation for aeromedical evacuation. Once in flight, the time and distance to higher levels of care are likely to increase; when this factor is combined with patients who may be less ready for flight, USAF care in the air may need to evolve. From a human performance perspective, future operations may bring a complex mixture of multiple domains and varying levels of automation. This may change the physical requirements for combat, and is likely to increase cognitive demand on operators. Fatigue may be a significant factor as demand on operators may increase. Finally, medical readiness needs may change based on these operations.

#### Learning Objectives

1. Understand the aeromedical implications of potential future U.S. Air Force operations.
2. Understand differences in future requirements for patient movement vs. human performance.

### [41] AEROMEDICAL CERTIFICATION USING GENERAL SYSTEMS PERFORMANCE THEORY

Thomas Van Dillen

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#### (Education - Program/Process Review)

**INTRODUCTION:** The determination of medical fitness to fly requires ascertainment of the pilot's current level of morbidity and estimation of the adequacy of piloting performance given that morbidity level. In the vast majority of dispositions, this determination is primarily based on the application of standards and medical examiner expert opinion as a functional capacity assessment would require access to a flight simulator. **TOPIC:** Theory provides an overarching explanation of how and why one would expect potential factors to predict an outcome. General Systems Performance Theory (GSPT) is offered as a promising theoretical perspective for explaining how and why morbidity level will predict human performance. The critical step in using GSPT as the theoretical perspective for medical certification is to focus on the effect of morbidity on the availability of human performance resources. GSPT posits that any system, to include the human system, can be logically decomposed into a set of performance resources. A performance resource is defined as a functional unit with a corresponding dimension of performance. Each performance resource contributes to a multi-dimensional performance space. The human-system task interface is then defined by resource economics. A task imparts performance resource demands on the human. Human performance resource availability must exceed task resource demand for all involved resources for successful task performance. As a result, a threshold (non-linear) relationship exists between task performance and resource availability. A performance resource will be limiting up to a task-determined threshold value, and thereafter more of the resource will not necessarily result in improved task performance. This relationship is empirically defined in GSPT through nonlinear causal resource analysis. **APPLICATION:** A set of pilot performance resources with an associated resource availability measurement battery can be identified that is suitable for use in the medical examiner office setting. By empirically establishing peak piloting task resource demand from human in the loop simulation studies, pilot performance resource availability minimum thresholds can be empirically established for use in aeromedical decision making. This approach is extensible to both existing and anticipated aerospace systems and thus accommodates changes in the human role in systems.

#### Learning Objectives

1. The audience will appreciate that globally, aerospace medicine is faced with the following challenges that must be addressed in this decade including understanding how medical certification is implemented through a hyper-safe operating environment and evolving from rule based to performance based medical standards.
2. The audience will appreciate the basic General Systems Performance Theory Key Concepts as any system (to include the human system) can be logically decomposed into a set of performance resources and a dimension of performance is always defined so that more of a resource is better.

### [42] ADVANCING EXPLORATION MEDICAL CAPABILITY THROUGH COORDINATED INTEGRATION OF RESEARCH, DEMONSTRATIONS AND SYSTEMS ENGINEERING

Jay Lemery, Kris Lehnhardt, Ben Easter

NASA Exploration Medical Capabilities, Houston, TX, United States

#### (Education - Program/Process Review)

**BACKGROUND:** NASA's Exploration Medical Capability focuses on clinical and scientific research, systems engineering and trade space analysis, and technology development and demonstrations—with goal of integrating progressively Earth-independent medical operations (EIMO) into future medical & vehicle systems for both Artemis & Mars.

**OVERVIEW:** Many facets are needed to optimize exploration medical systems, and the ExMC is endeavoring an unprecedented degree of research integration amongst ground development & testing; adoption of new approaches to medical protocols & procedures; deployment into analog environments; technology demonstrations on ISS, in lunar orbit, & on the lunar surface; and transition to operations for deep space exploration missions. **DISCUSSION:** The ExMC has undertaken a three-pronged approach to promulgate a progressively Earth-independent medical research agenda through: answering key clinical and science research questions: applying systems engineering processes to medical system design to yield robust requirements for integration into future space exploration vehicle designs; developing and demonstrating novel medical technologies to improve future medical capabilities in space. ExMC has supported a diverse foundation to inform future EIMO work for long-duration missions. Successful examples include in situ analysis of blood and medical procedure support via AMOS (autonomous medical officer support) as well as enhancing onboard resource efficiencies via intravenous fluid generation and medical consumables tracking. The Element has yielded invaluable insights on pharmaceutical stability as well as assessments of pharmacodynamics and pharmacokinetics. Integrated data architecture and clinical decision support tools supported by ExMC have advanced the research agenda around numerous facets of autonomous medical systems. Its medical system model design work, linking concept of operations, NASA standards and medical conditions will inform medical system requirements to serve as a foundation for long duration mission requirements. Finally the IMPACT trade space analysis tool suite will allow for sophisticated, informed decision making by analyzing numerous medical and non-medical variables of long duration spaceflight. By highlighting the above work, this presentation will focus on scientific and technical conceptual drivers for the Element, the current and future research risks and gaps, future strategic direction of the Element.

#### Learning Objectives

1. Understand the strategy and rationale for advancing earth independent medical operations.
2. Understand the foundational work of the NASA Human Research Program ExMC Element.
3. Understand the future research challenges of Earth Independent Medical Operations [EIMO].

#### [43] AEROMEDICAL AND HUMAN PERFORMANCE CHALLENGES OF FUTURE US NAVY AND MARINE CORPS AIRCRAFT

Richard Arnold

Naval Medical Research Unit Dayton, Wright-Patterson AFB, OH, United States

#### (Original Research)

The U.S. Navy and Marine Corps are undergoing significant changes in several of their principal airframes that support key operational missions. The F-35 Lightning II will replace the Navy's F/A-18 family of carrier based tactical aircraft with the F-35 C, and the USMC is acquiring the F-35 B short takeoff and vertical landing (STOVL) variant. On the rotary wing front, although the US Army leads the DoD's future vertical lift (FVL) program, the Navy and Marine Corps have significant stakes in the program with likely replacements to existing rotary wing and tilt-rotor platforms to be selected via the FVL program. Lastly, the Navy has recently transitioned from the C-2 to the CMV-22 tilt-rotor for carrier onboard delivery (COD). The CMV will also be utilized for patient transport in the maritime domain. Aspects of these new platforms present new aeromedical and human performance challenges. This panel presentation will discuss recent, ongoing, and planned aeromedical, physiological, and human performance-related research that will inform aeromedical and human performance solutions to anticipated challenges posed by these new aircraft. For example, recent and ongoing research on the role of cognitive workload in contributing to pilot spatial disorientation can inform

a better understanding of pilot performance in the information-rich cockpit of 5<sup>th</sup> generation fighters such as the F-35. The CMV-22 platform will extend the Navy's capabilities for patient transport in the maritime environment. However, long transport times in unpressurized aircraft presents novel challenges for patient transport in maritime operations. This panel presentation will discuss research findings and identified research gaps responsive to aeromedical and human performance challenges presented by these new airframes.

#### Learning Objectives

1. The audience will learn about research addressing pilot workload and situational awareness.
2. The audience will learn about emerging concepts and research on patient movement in maritime operations.

**Monday, 05/22/2023**  
**Napoleon C3**

**10:30 AM**

#### [S-09]: SLIDES: HUMAN PERFORMANCE UNDER AEROSPACE STRESS

**Chair: Douglas Boyd**

**Co-Chair: Chuck DeJohn**

#### [44] USING THE WHIPPET FACILITY TO MONITOR LINGERING EFFECTS OF MODERATE ALTITUDE EXPOSURE ON SIMULATED PRECISION FLIGHT CONTROL

Jeremy Beer<sup>1</sup>, Bria Morse<sup>1</sup>, Todd Dart<sup>1</sup>, Paul Sherman<sup>2</sup>

<sup>1</sup>KBR Science & Space, San Antonio, TX, United States; <sup>2</sup>U.S. Air Force 59th Medical Wing and USAFSAM, San Antonio, TX, United States

#### (Original Research)

**INTRODUCTION:** The WHIPPET (Wayfinding, Hypoxia, and Interceptive Performance in Pilots Executing Transitions) simulation concept was evaluated to measure effects of moderate altitude exposure on visual vehicle control in a limited subject group. The facility combines visual flight simulation with an accurate cockpit model in a reconfigurable hypobaric chamber environment. Objectives were to detect subtle piloting deterioration and monitor physiological processes throughout exposure and recovery. **METHODS:** Seven subjects trained to perform precision instrument control (PICT) flight and unusual attitude recovery (UAR), and then completed chamber flights dedicated to the PICT and UAR respectively. Each flight comprised five epochs including ground level pressure (GLP), ascent through altitude plateaus at 3050m, 4270m, and 5338m, then post-exposure recovery. PICT performance was assessed using RMS-based flight simulator error (FSE) and time-out-of-bounds (TOOB). UARs were assessed using time to achieve level (RTT), initial response time (RTI) and time to first correct input (RTC). Physiological indices included SpO<sub>2</sub>, heart rate (HR), end tidal O<sub>2</sub> and CO<sub>2</sub> pressures (P<sub>et</sub>O<sub>2</sub>, P<sub>et</sub>CO<sub>2</sub>), and respiration. Analysis comprised repeated-measures ANOVA using Epoch as the independent factor. The study was conducted in compliance with human subject protection regulations. **RESULTS:** Altitude influenced PICT performance; higher FSE was recorded at 5338m and Recovery than GLP, and TOOB was longer during Recovery. UAR effects were less clear; RTT and RTI responses accelerated during and after exposure respectively. Physiological altitude effects included elevated HR and ventilation, decreased S<sub>p</sub>O<sub>2</sub>, P<sub>et</sub>O<sub>2</sub>, P<sub>et</sub>CO<sub>2</sub>, and slowed respiration during Recovery. **DISCUSSION:** The concept evaluation was successful; subtle piloting impairment and physiological responses were detected during exposure. Lingered effects on certain metrics were monitored during recovery. Whereas S<sub>p</sub>O<sub>2</sub> has been employed as an indicator of altitude effects, the precision piloting effects measured here are interpreted in a context of corollary physiological processes including respiration and hypocapnia. It is proposed that certain underlying compensatory mechanisms operate across a longer timeframe than post-exposure S<sub>p</sub>O<sub>2</sub> recovery, which is typically rapid. Potential areas for future research

include implications and monitoring of effects on precision piloting during recovery.

#### Learning Objectives

1. The audience will understand the demonstration of a physical apparatus and empirical approach to assess effects of challenging conditions including hypobaric hypoxia on performance in a synthetic piloting task.
2. The audience will understand the monitoring of slight increases in piloting error and changes in physiology and respiration metrics during and after hypobaric exposure.

### [45] MODERATE HYPOXIA IMPAIRS AND MODERATE EXERCISE PARADOXICALLY IMPROVES PERFORMANCE ON A VISUAL TRACKING TASK

LCDR Joseph Geeseman<sup>1</sup>, Olivia Fox Cotton<sup>2</sup>, Kim Prisk<sup>3</sup>, Janelle Fine<sup>3</sup>, Justin Morgan<sup>2</sup>, Kevin Durkee<sup>2</sup>, John Feeney<sup>2</sup>

<sup>1</sup>U.S. Navy, Patuxent River, MD, United States; <sup>2</sup>Aptima, Inc, Dayton, OH, United States; <sup>3</sup>University of California-San Diego, San Diego, CA, United States

#### (Original Research)

**INTRODUCTION:** Cognitive performance suffers under hypoxic conditions and visual tracking tasks can assess this. Personnel exposed to hypoxia are often required to perform some degree of exertion, potentially increasing the degree of impairment that results from hypoxia alone. In this study, participants performed a ball tracking task while exercising on a stationary bicycle breathing a normobaric or moderate hypoxic gas.

**METHODS:** The tracking task, ran on a 13-inch tablet, manipulated ball speed, occlusion, and starting side to vary trial difficulty and measure performance degradation in response to imposed physiological stress. Subjects (n=7, 4 female, aged 18-38 yr) were exposed to normobaric normoxia and hypoxia (FIO<sub>2</sub> 0.21 and 0.125) and to a low to moderate level of exercise (5W, 50W). The mean pixel distance to target measure of performance (lower = better) was used in each trial. **RESULTS:** Hypoxia at low exercise reduced arterial O<sub>2</sub> saturation (99.4±0.7 [mean±SD], 89.4±4.3, P<0.001, ANOVA), while moderate exercise did not lower normoxic SaO<sub>2</sub> (99.5±0.6, P=0.97). Hypoxia + moderate exercise resulted in a SaO<sub>2</sub> (88.0±5.7, P<0.001). In all trials the best performance was with slow speed and no occlusion, (38.1±13.9) for low exercise normoxia compared to (85.0±26.0, P<0.001) for fast speeds and occlusion under the same condition. For the easiest trials (slow, no occlusion) there was no main effect of hypoxia (37.7±13.2 normoxia; 40.8±10.8 hypoxia, P=0.5) or of exercise (39.3±12.5 low exercise; 39.1±11.8 moderate exercise, P=0.9). For the hardest trials (fast, occluded) there was a main effect of hypoxia increasing mean distance (79.9±22.9 normoxia; 91.3±41.6; hypoxia P=0.0005) but a main effect of exercise level reducing mean distance (89.9±39.5 low exercise; 81.4±26.9 moderate exercise; P=0.009).

**DISCUSSION:** Modest hypoxia impaired performance in more challenging trials, but not in easier trials. Modest exercise had minimal effect on the easier trial, but a paradoxical improvement in performance in challenging trials. The results suggest that the tablet-based task provides subjects a sensitive and graded degree of challenge. Why a modest level of exercise was associated with improved performance requires further investigation.

#### Learning Objectives

1. The audience will learn about the effects of hypoxic conditions and physical exertion on cognitive performance.
2. The audience will learn about physiological changes experienced during hypoxic conditions.

### [46] SEX COMPARISONS OF PHYSIOLOGICAL AND COGNITIVE PERFORMANCE DURING HYPOXIC CHALLENGE

Kaila Vento<sup>1</sup>, Cammi Borden<sup>2</sup>, Caitlin O'Guin<sup>3</sup>, Kara Blacker<sup>1</sup>

<sup>1</sup>Naval Medical Research Unit-Dayton, Wright-Patterson AFB, OH, United States; <sup>2</sup>Oak Ridge Institute of Science and Education, Wright-Patterson AFB, OH, United States; <sup>3</sup>Leidos, Wright-Patterson AFB, OH, United States

#### (Original Research)

**INTRODUCTION:** A poor understanding of potential sex differences on aeromedically relevant environmental stressors could lead to suboptimal performance, safety, and health guidelines. To illustrate, the threat of hypoxia and its possible contribution to recent unexplained physiological events are at the forefront of human performance research and operations. Yet, progress toward sensor development and improving hypoxia training are stunted due to limited knowledge of how individual characteristics, including sex, potentially underlie hypoxia symptoms and performance impairment. Therefore, we retrospectively investigated whether sex was a predictor of physiological and cognitive performance during hypoxic challenge. **METHOD:** N=116 (male, n=78; female, n=38) participant datasets were combined from 6 previous experimental hypoxia studies. Separate stepwise linear regression models analyzed the independent variables (i.e., Model 1= sex, age, and BMI; Model 2= altitude and exposure minutes) on the dependent variables (i.e., SpO<sub>2</sub>, heart rate, neural modulation, cognitive performance, hypoxia-related symptom frequency). Additional binary (yes/no response) logistical regression models analyzed the above independent variables on each hypoxia-related symptom. The NAMRU-D's Institutional Review Board approved all 6 previous hypoxia studies. **RESULTS:** Female sex predicted lower SpO<sub>2</sub> (p<.001), though in combination with age and BMI alone, explained only 6% of the variance. Female participants were 3.33 times more likely to report a headache (P=0.02), during hypoxia. Age significantly predicted decreased heart rate and was associated with increased reports of hot flashes, headaches, and fatigue, all P<0.05. Expectedly, increased altitude significantly predicted lower SpO<sub>2</sub>, higher hypoxia-related symptom frequency scores, and increased reports of several individual symptoms, all P<0.05. The neural modulation and cognitive performance models did not converge, suggesting high intra-individual variability. **DISCUSSION:** The current study found that sex, age, and BMI were not the most robust predictors in responses to hypoxic challenge. The knowledge gained will help to refine hypoxia familiarization training, enhance the precision of monitoring sensor development, and update emergency response and recovery protocols in the event of a hypoxia occurrence suitable for all aircrew.

#### Learning Objectives

1. Address any potential sex-specific disparities in aeromedically relevant environmental stressors.
2. Understand the physiological and cognitive repercussions during hypoxic challenge between sexes.

### [47] HEART RATE VARIABILITY AS AN OBJECTIVE MEASURE FOR LOW BACK DISCOMFORT: A POTENTIAL METHOD FOR EVALUATING AIRCREW SEATING ENDURANCE

Peter Le

Air Force Research Laboratory, Wright-Patterson AFB, OH, United States

#### (Original Research)

**INTRODUCTION:** Non-neutral seating postures commonly seen in military aviation are associated with low back pain (LBP) and subsequent reports of fatigue and distraction. However, given the variability and hesitance of subjective discomfort reporting among aviators, an objective measurement is needed to understand discomfort and its impact on aircrew seating endurance. Recent work in the physical ergonomics literature employed heart rate variability (HRV) as an approach to investigate whole-body discomfort. Variation between the R-R peaks represent the fluctuation between sympathetic and parasympathetic responses. Within the frequency domain, an increased low-frequency to high-frequency ratio (LFHF) has been associated with increased physical discomfort. The aim of this study was to evaluate physiologic discomfort through HRV during prolonged seating in a non-neutral posture with an axial load. This is a subset of a larger study investigating low back fatigue and trunk stability. **METHODS:** Twenty participants (10M, 10F) sat for three continuous hours in a simulated helicopter seat while wearing a 20lb weighted vest to simulate aviator equipment. Heart rate data were

collected and variability between R-R peaks were assessed in 30-minute epochs in the frequency domain. Stepwise logistic regression was used to evaluate anthropometry, time, and LFHF associations with subjective reports of low back discomfort. **RESULTS:** Statistically significant ( $\alpha=0.05$ ) differences were seen over time in the LFHF ratio ( $p=0.0341$ ) with the lowest value occurring in the first 30-minute time block. Logistic regression showed an association between time, the LFHF ratio, and anthropometry in predicting low back discomfort ( $p<.0001$ ). **DISCUSSION:** The LFHF ratio increased over time and followed the same trend as reported low back discomfort. Through logistic regression, anthropometric variables (sex, age, shoulder width, sternum depth, head width) alongside the LFHF ratio and time were able to predict low back discomfort. These findings are in agreement with published work investigating anthropometric associations with physiologic measures in predicting discomfort for automotive seat design. Collectively, these results suggest a need for quantifying discomfort through the interaction of physiologic measures and individual differences. Quantifying and understanding these changes may provide insights into aircrew seating endurance and methods to qualify future aircraft seat designs.

#### Learning Objectives

1. The audience will learn how heart rate variability may be used to investigate discomfort during low-level physical loading.
2. The audience will learn how discomfort/seating endurance is multifactorial through the interaction of anthropometry and physiological measures.

#### [48] INITIAL TRIAL TO INVESTIGATE THE FEASIBILITY AND FIDELITY OF THE ROYAL CANADIAN AIR FORCE AIRCREW CONDITIONING PROGRAM

Erin Smith<sup>1</sup>, Reilly Tara<sup>2</sup>, James Anderson<sup>3</sup>, Andrea Bowman<sup>4</sup>, Kelly Debouter<sup>5</sup>, Thomas Karakolis<sup>6</sup>, Tyler Kung<sup>2</sup>, Kathleen Schmit<sup>7</sup>, Alyssa Sims<sup>8</sup>

<sup>1</sup>Canadian Forces Environmental Medicine Establishment, Toronto, ONT, Canada; <sup>2</sup>Canadian Forces Morale & Welfare Services, Ottawa, ONT, Canada; <sup>3</sup>Canadian Forces Morale & Welfare Services, Moose Jaw, Saskatchewan, Canada; <sup>4</sup>Canadian Armed Forces, Comox, British Columbia, Canada; <sup>5</sup>Canadian Armed Forces, Ottawa, ONT, Canada; <sup>6</sup>DRDC, Toronto, ONT, Canada; <sup>7</sup>Canadian Armed Forces, Shilo, Manitoba, Canada; <sup>8</sup>Canadian Forces Morale & Welfare Services, Edmonton, Alberta, Canada

#### (Original Research)

**INTRODUCTION:** More than 90% of RCAF aircrew report significant flight-related neck pain (Smith, 2021). One solution is strength and conditioning programs (Ang, 2009; Salmon, 2011). As recommended by the NATO HFM RTG 252 (Farrell, 2020) and demonstrated by the RAF and RAAF, the Aircrew Conditioning Program (ACP) effectively reduces/prevents neck injury, reduces time away from flying and improves performance (Slungaard, 2018; Slungaard, 2019; Wallace, 2019). With direction from CFEME, the RCAF adopted a modified ACP at 408 Squadron and 2 Canadian Forces Flying Training School (CFFTS). Implementation required a dedicated Physical Exercise Specialist (PES) and commitment from RCAF leadership to mandate that all aircrew complete a minimum of two RCAF ACP training sessions per week. **METHODS:** Evaluation included objective (physiotherapy, fitness assessments) and subjective (surveys) metrics to determine (1) effectiveness, and (2) feasibility to implement a similar program across the RCAF. Metrics were collected at baseline and 3, 6, 12 month intervals. Effectiveness was determined by physical testing and survey responses. Program feasibility was assessed via: (1) resource utilization and CAF personnel availability, (2) compliance, and (3) evolutions to the program. **RESULTS:** From baseline to 3-months, 408 Sqn aircrew improved deep neck flexor endurance by 26.4s, but decreased by 17.1s from 3 to 6-months. At 2 CFFTS, DNF improved from baseline to 3-months by 28.4s and 44.6s (Group 1&2), and improved from 3-6 months by 22.1s and 11.71s (Group 1 & 2). At 408 Sqn, compliance was 56% in week 1, 5% in week 12 and <5% in week 24. At 2 CFFTS, compliance in Groups 1&2 was 94%

and 92% in week 1, 47% and 79% in week 12 and 33% and 71% in week 24, respectively. **DISCUSSION:** Objective testing suggests that the RCAF ACP is effective after 12 weeks of training. However, effectiveness is reliant on compliance. Low compliance prevented program progression at 408 Squadron. The structured environment at 2 CFFTS facilitated better attendance/compliance. Challenges included scheduling, limited ability to progress and the perceived risk of injury/grounding. Future work must include additional efforts to identify/remove barriers, maximizing participation. While awaiting implementation of the RCAF ACP at other bases, all aircrew are encouraged to follow a conditioning program which focuses on total body/core fitness, and supervised isometric neck-specific exercises.

#### Learning Objectives

1. The audience will learn about the development of the RCAF ACP and initial trial implementation of this program at two RCAF flying units.
2. The audience will learn about the results of the initial trial of the RCAF ACP, the effectiveness and feasibility of the program and future proposed work.

#### [49] HYDRATION, BLADDER RELIEF, & HUMAN PERFORMANCE IN MILITARY AVIATION

Kelly VandenBossche, Mark Harvie, Billie Flynn  
Omni Defense Technologies, Colchester, VT, United States

#### (Education - Program/Process Review)

**BACKGROUND.** Maintaining peak performance requires the ingestion of fluids before, during, and after activity. With adequate fluid intake, the human body produces approximately 50 to 100mL of urine/hour. Because of the limitations of most available bladder relief systems (BRS) for voiding urine produced, military aviators often avoid taking in enough fluids, leading to dehydration, suboptimal cognitive and physical performance, and potentially grounding health issues. The majority of available BRS are cumbersome and decrease safety during use. In the US Air Force (USAF) alone, there have been at least 10 class 'A' mishaps that were attributed, at least in part, to fumbling with piddle packs. In 2001, USAF recognized this capability gap and wrote the first Small Business Innovative Research grant for development of a state-of-the-art BRS. Since then, BRS's have been continuously improved through extensive research, development, test and evaluation efforts. **OVERVIEW.** Thirty USAF pilots and aircrew who flew in ejection seat aircraft participated in 3<sup>rd</sup> generation developmental test (DT). After each test phase, findings and recommendations from the debrief were integrated into the design for the subsequent phases, following a 'fly-fix-fly' process. Upon completion of DT, the BRS was tested in the flight environment resulting in 'Safe To Fly' approval. **DISCUSSION.** The outcome is a BRS that's hands-free, eyes-free, and automatic, meeting the stringent requirements of military aviators and the harsh aviation environment. It increases safety in military flight operations, and allows aviators to hydrate rather than avoiding fluid intake, or "tactically dehydrating." By maintaining normal body water levels, the aviator doesn't experience the physical and cognitive performance degradations that are brought on by dehydration. Although operating tactical jet aircraft is a well-known example of an occupation that makes bladder relief difficult and hazardous, multi-piloted aircraft – especially those with mixed gender crew; firefighters; and CBRN Response enterprise are occupations that will also benefit from trouble-free BRS. More importantly, individuals will be able to maintain high physical and cognitive readiness through proper hydration. This presentation will discuss the latest research efforts and will also delve into the effects of dehydration on performance, hydration recommendations, and available BRS for military aviators.

#### Learning Objectives

1. The audience will understand the physiological effects of dehydration on physical and cognitive performance, especially as it relates to military aviation.
2. The audience will understand the relationship of fluid intake to human performance and will learn what are the current fluid intake recommendations to prevent dehydration.

3. The audience will learn about the research, development, test, and evaluation efforts for bladder relief systems as well as the current options available for in-aircraft bladder relief.

**Monday, 05/22/2023**  
**Nottoway & Oak Alley**

**10:30 AM**

## **[S-10]: SLIDES: MENTAL HEALTH & CERTIFICATION**

**Chair: Anthony Wagstaff**

### **[50] A PROPOSED RESEARCH FRAMEWORK TO STUDY AEROMEDICAL CERTIFICATION OF PILOTS WITH A MENTAL HEALTH CONDITION.**

William Hoffman<sup>1</sup>, Anthony Tvaryanas<sup>2</sup>

<sup>1</sup>Brooke Army Medical Center, Fort Sam Houston, TX, United States;

<sup>2</sup>FAA CAMI, Oklahoma City, OK, United States

(Education - Program/Process Review)

**BACKGROUND:** U.S. pilots are required to disclose symptoms of, a diagnosis or treatment for a mental health condition during screening conducted as part of periodic aeromedical examinations due to safety concerns for incapacitation or degraded performance in flight. But while mental health symptoms are common in pilots, evolving data suggest many pilots avoid healthcare and/or withhold information during aeromedical screening due to fear for aeromedical certificate loss. This phenomenon is proposed to result in negative consequences to the pilot, prompting stakeholders to call for an alternative approach to aeromedical certification related to mental health. Data to guide a change in policy are lacking and an organized research framework is necessary. **OVERVIEW:** We propose a theoretical framework to guide research efforts related to aeromedical certification of pilots with a mental health condition. It is hypothesized that a certain burden of mental health symptoms results in a negative impact to pilot performance, but this clinical point is undefined. Using principles of population health, the framework includes the proposed distribution of mental health symptoms in the population of pilots. It also identifies the following points: (1) the burden of mental health symptoms that results in a negative impact to performance (aeromedically significant disease), (2) the proportion of pilots identified with a mental health condition using current aeromedical screening practices, and (3) the ideal proportion of pilots identified with a mental health condition using future, yet undefined, aeromedical screening practices. **DISCUSSION:** Stakeholders are calling for an alternative approach to aeromedical certification related to mental health and we present a theoretical research framework to study this complex clinical, regulatory and safety question. The model is complimentary to and augments existing Safety Management System (SMS) programs (Federal Aviation Administration (FAA) Order 8000.369) by adding a population health consideration to current safety models. Benefits of such a model include (1) guiding a multi-institutional research agenda, (2) promoting a shared use of terms, and (3) facilitating communication of clinical and safety research questions with stakeholders.

#### **Learning Objectives**

1. Identify current aeromedical screening objectives related to mental health and the subsequent impact to pilot healthcare seeking behavior.
2. Identify the following points in the proposed research framework: (1) distribution of mental health symptoms in the population, (2) the burden of mental health symptoms that results in a negative impact to performance, (3) the proportion of pilots identified with a mental health condition using current and future screening practices.
3. Identify how the proposed research framework might support (1) guiding a multi-institutional research agenda, (2) promoting a shared

use of terms, and (3) facilitating communication of clinical and safety research questions with stakeholders.

### **[51] CASE REPORT – CAN A DIAGNOSED WITH AUTISM WITH AUTISM SPECTRUM DISORDER BECOME AN AIRLINE PILOT?**

Eran Schenker

Civil Aviation Authority Israel, Tel Aviv, Israel

(Original Research)

**METHODS:** A 21-year-old male has applied for a medical certificate as part of his desire to become an airline pilot. The AME explained to the candidate that it would be difficult to diagnose if his social and communication limitations were barriers to getting the wings he had been dreaming of for many years. However, the AME decided to request a medical waiver from the flight surgeon at the Civil Aviation Authority in Israel (CAAI). **RESULTS:** After a comprehensive set of psychologist assessments, the candidate has been approved for a medical certificate with a medical waiver as the first step to embark on an aviation career. **DISCUSSION:** The CAAI, like the FAA, identifies several disqualifying medical conditions, including several psychological ones. Autism spectrum disorders aren't listed as such. The knowledge, skills, and experience requirements for completing training and licensure are all performance-based. Log the hours, pass the tests, and you're a pilot. Since Some believe that flying an airplane is substantially about rote procedures and cut-and-dry technical knowledge, many individuals on the spectrum probably may pull it off. But is it safe? Asperger syndrome is an autistic spectrum disorder characterized by impaired social interaction and restricted, repetitive, and stereotyped behavior patterns. The DSM-5 diagnostic criteria also include significant impairment in social or occupational functioning. Nevertheless, if language skills and cognitive development are not impaired and someone diagnosed with Asperger's syndrome may be able to acquire the skills necessary to function safely as a pilot or air traffic controller. Interpersonal difficulties may arise or emerge in the Crew Resource Management environment of the modern professional airline cockpit.

#### **Learning Objectives**

1. The audience will learn about the FAA guide on disqualifying medical conditions, including several psychological ones which Autism spectrum disorders aren't listed as such.
2. The audience will learn about Autism and flying. Autism has been significantly redefined in recent years to where there is no real definition anymore.
3. The audience will learn how to establish the correct assessments to declare if an Autism Spectrum Disorder aviator candidate passes the medical ANE exam.

### **[52] FAA SSRI PROGRAM: A WIN-WIN FOR PILOT MENTAL HEALTH AND FLYING CAREERS**

Christopher Flynn

FAA, Washington, DC, United States

(Original Research)

**INTRODUCTION:** Since May 2010, the FAA has approved the use of four Selective Serotonin Reuptake Inhibitors (SSRI) medications for aviator psychiatric treatment and medical certification. Data are presented on aviators who are successfully in treatment and flying in the FAA SSRI Special Issuance (SSRI-SI) program. **METHODS:** Basic mental health information for every SSRI-SI aviator is reviewed annually by an FAA psychiatrist. Between October 2019 and August 2022, diagnostic information and renewal status was captured on 501 SI airmen. In a convenience sample of 150 aviators: psychiatric history, medical classification, age, antidepressant years of use, and flying hours were reviewed. **RESULTS:** Overall, 474 (95%) of 501 aviators continued their SI without interruption, while 27 (5%) had their SI stopped due to worsening symptoms, lack of regulatory compliance or change in medication use. Of the 27 with an interrupted SI, 9 returned to flying: a total of 483 aviators (96%). SI aviators with complex psychiatric histories were able

to participate: 299 (60%) had 1, 167 (33%) had 2 and 45 (9%) had 3 or more psychiatric conditions. In SI aviators: 322 (64%) had Anxiety, 287 (60%) had Mood, 71 (14%) had CFR Substance conditions and 85 (17%) had Other Disorders. In a sub-group of 150 SI aviators, 32 (21%) had combined use of 2+ psychiatric medications, 11 (7%) had past suicidal ideation, 8 (5%) had past psychiatric hospitalization, 5 (3%) had an unsubstantiated history of bipolar illness, 4 (3%) had combined use of 2+ antidepressants. Continuous antidepressant use was 8.8 years (SD, +/- 5.8 years), and 48 (32%) were taking an antidepressant before the FAA SSRI-SI program began in May 2010. **DISCUSSION:** Aviators may develop mental disorders that require psychiatric treatment, including medications. Since May 2010, the FAA has returned aviators with a wide range of diagnoses and psychiatric histories (including intensive treatment) to flying, when they met policy and health requirements – and it was safe to do so. Of 501 current SSRI-SI aviators, 96% were successfully flying during this 34 months period. The FAA SSRI-SI program succeeds at encouraging aviators to receive psychiatric treatment while continuing their flying career.

#### Learning Objectives

1. The participant will be able to reflect the substantial benefit for pilots who seek mental health treatment on their ability to maintain their careers.
2. The participant will be able to express that pilots with a wide range of mental health diagnoses were successfully flying in the FAA SSRI program.
3. The participant will be able to identify that there was a 96% success rate for pilots to continue flying during this 34-month period.

#### [53] A PERFORMANCE-CENTERED MENTAL HEALTH AND WELLBEING CURRICULUM FOR COLLEGIATE STUDENT PILOTS.

Reyné O'Shaughnessy

Duquesne University, Pittsburgh, PA, United States; Brown University, Providence, RI, United States; University of California-Berkeley, Berkeley, CA, United States; Functional Medicine Academy, Pittsburgh, PA, United States

#### (Education - Program/Process Review)

**BACKGROUND:** Aircraft pilots function in highly complex, safety-critical environments that demand high cognitive and physical performance. This requires pilots to maintain adequate physical and mental wellbeing. The importance of wellbeing in aviation is growing due to (1) evolving data demonstrating its role in performance, (2) increasing relevance following the effects of the SARS-CoV-2 pandemic on wellbeing and mental health, and (3) factors such as pilot burnout and lower retention rates. However, while the importance of aviator wellbeing is becoming increasingly clear, many collegiate aviation training programs lack formal wellbeing and mental health curriculum, i.e. non-technical skills (NTS). **OVERVIEW:** To fill this gap, we have proposed a performance-centered mental health and wellbeing curriculum catering to collegiate student pilots. The curriculum includes four virtual modules designed to complement an established technical flight training program: (1) fundamentals of sleep, (2) nutrition for wellness and performance (3) exercise science for aviators, and (4) mindfulness tailored for aviators. The relevance of such a program was demonstrated through survey results from collegiate students where ninety-four percent of students indicating that mental health and wellbeing training can positively address their general health and wellbeing. **DISCUSSION:** The importance of wellbeing in aviators is becoming increasingly clear. The aim is to provide student pilots with critical tools to build and maintain their wellbeing throughout their aviation career. It is hypothesized that building wellbeing skills can build safety and positively improve operational safety and efficiency by expanding the skill sets of pilots. NTS training supports the operational safety and efficiency of civilian, international, and military aviation spheres. Within military spheres, it has been suggested that NTS training can improve individual and team combat skills. Within the civilian and international sphere, NTS training may boost safety and performance in

unexpected situations through improved teamwork and communication. Future research questions could include the impact of curriculum on (1) performance outcomes, (2) airline costs savings due to burnout, and (3) improved physical and mental health.

#### Learning Objectives

1. The audience will learn about a curriculum that complements the technical side of a traditional aviation training program.
2. The audience will learn the four critical tools (NTS) of health in order to build and maintain wellbeing.
3. The audience will learn about why we sleep and why it is the bedrock to health.

#### [54] HOW DOES A SUCCESSFUL AIRLINE-BASED ALCOHOL AND OTHER DRUG REHABILITATION PROGRAM EFFECTIVELY PROMOTE RECOVERY IN WORKERS WITH SUBSTANCE ABUSE ISSUES

Julia Myers<sup>1</sup>, Ben Johnston<sup>2</sup>, Giles Newton-Howes<sup>1</sup>, Elliot Bell<sup>1</sup>, Jessica Nairn<sup>3</sup>

<sup>1</sup>University of Otago, Wellington, New Zealand; <sup>2</sup>Air New Zealand, Auckland, New Zealand; <sup>3</sup>Capital Coast and Hutt Valley District, Te Whatu Ora Health New Zealand, Wellington, New Zealand

#### (Original Research)

**INTRODUCTION:** Limited published evidence suggests alcohol and other drug (AOD) rehabilitation programs specific to professional groups such as pilots and doctors achieve high success rates compared to standard programs. The reasons for this are unclear. This research focused on gaining an in-depth understanding of how a workplace AOD program effectively facilitates individuals with substance abuse issues to achieve and maintain recovery, based on the perspectives and experiences of those who have engaged with a successful airline-based AOD program.

**METHOD:** During 2022, eight current airline employees in recovery, and six doctors currently or formerly associated with the airline medical unit, were interviewed in-depth. A qualitative grounded theory approach was used to conceptualize and develop an explanatory model of how an airline-based program effectively promotes recovery for workers with diagnosed substance abuse disorders. **RESULTS:** Themes developed from the interview data illustrate how the characteristics of individuals, programs, and workplace culture, play crucial and interconnected roles in supporting recovery. The individuals in recovery possess high internal motivation to return to work; they have invested in a career they love and see it as a key part of their identity. Already familiar with an employment structure contingent on the need to undergo regular evaluations to demonstrate their fitness to work, they are kept "on track" by a balance of motivators (carrots) and consequences (sticks) through both soft and hard mandates. Key aspects of the program include early and accessible specialist input and a strong emphasis on facilitating involvement with peer networks. Culturally, the workplace is seen as providing an optimal environment within which recovery succeeds, combining the aviation-specific emphasis on safety with a "just culture" focused on doing the right thing. Crucially, buy-in from the company is tangible, making those in recovery feel valued, and facilitating the development of mutual respect and trust between workers, management, medical staff, and the regulator. **DISCUSSION:** These study findings assist in understanding how airlines can effectively support workers requiring AOD rehabilitation and point to the overarching importance of company culture. Programs based on these principles can increase aviation safety and also make good business sense.

#### Learning Objectives

1. The audience will understand how company culture can effectively support airline-based workers diagnosed with substance abuse disorders to successfully achieve and maintain recovery.
2. The audience will understand how interconnected features of the individual workers, program makeup and company culture impact on the success of an airline-based AOD rehabilitation program.

**[55] WHEN EATING BREAD BEFORE FLIGHT CAN BE A PROBLEM**

Sarita Dara, Tim Sprott, Claude Preitner

*Civil Aviation Authority of New Zealand, Wellington, New Zealand***(Education - Case Study)**

**INTRODUCTION:** Consumption of poppy seed (PS) containing products can result in opiate-positive urine drug screen (UDS) results and pose challenges in distinguishing PS consumption from opiate administration. A preflight nonnegative UDS has serious implications from an aviation medical certification perspective. **BACKGROUND:** This case discusses approach to assessment of an aircrew with opiate positive UDS. The aircrew claimed that PS containing bread that was consumed preflight, explained the non-negative UDS. Studies analyzing opium alkaloids in PS suggest that there is huge variation in morphine and codeine levels between the same batch and between sources of PS. Variation in alkaloid levels is attributed to many factors: season, harvesting and thermal processing. Grinding and baking of PS can reduce morphine content by 50 - 80%. General guidance for interpretation of UDS is that codeine concentration >300 ug/L coupled with a morphine to codeine ratios of <2 are generally indicative of codeine consumption. In recent times, there are reports of individuals who produced codeine-positive and morphine negative UDS, and who denied codeine use, attributing their test results to the consumption of PS containing food. Specific marker for PS ingestion is Thebaine, which can be tested and reported by the laboratory. **CASE PRESENTATION:** A 25-year-old aircrew returned a non-negative UDS test for codeine, as part of a random preflight check. The results were the same on a repeat UDS. He was stood down from flying. UDS results were confirmed by mass spectroscopy with codeine positive above cut off levels of 300ug/L and morphine was not detected. Aircrew denied taking codeine containing medications or substances but attributed the non-negative test result to consumption of PS bread prior to reporting for flight. Aircrew stopped taking the bread and repeated the UDS a few days later and this was negative for opiates. Further detailed analysis was done of the initial urine samples and these showed high levels of codeine (1000ug/L -2500ug/L) with non-detectable morphine (<300ug/L). The reanalysis also detected thebaine in both the urine samples, which is an opium alkaloid specifically found in poppy seeds. Further UDS test done a few weeks later was negative. **DISCUSSION:** This presentation will highlight the approach to interpretation of UDS result and draws on the best available evidence to determine aeromedical disposal of an atypical non-negative UDS in an aircrew.

**Learning Objectives**

1. The audience will learn about the approach to interpretation and analysis to opiate positive urine drug screen (UDS) in an aircrew.
2. The participant will be able to understand the various factors that need to be considered when presented with an atypical UDS screen.
3. The audience will learn about the current evidence about interpretation of opiate positive UDS and claims related to poppy seed consumption.

**Monday, 05/22/2023**  
**Grand Ballroom A-B-C**

**2:00 PM**

**[S-11]: SLIDES: THERE'S AN APP FOR THAT...  
 MEDICAL DEVICES IN SPACE**

**Chair: Ben Easter****Co-Chair: Samantha King****[56] OPTIMAL FORMULATION FOR AN INFLIGHT ULTRA-COMPACT URINARY CALCIUM MEASUREMENT DEVICE**

Mimi Lan<sup>1</sup>, Darin Knaus<sup>2</sup>, Clive Devoy<sup>2</sup>, Kate Fergusson<sup>2</sup>, Scott Phillips<sup>2</sup>, Jay Buckley<sup>3</sup>

<sup>1</sup>Thayer School of Engineering at Dartmouth, Hanover, NH, United States;<sup>2</sup>Creare LLC, Hanover, NH, United States; <sup>3</sup>Geisel School of Medicine at Dartmouth, Lebanon, NH, United States**(Original Research)**

**INTRODUCTION:** Spaceflight bone loss and kidney stone prevention programs are currently assessed postflight for effectiveness. Inflight assessment would enable a preventative approach, where countermeasures could be adjusted and individualized for each astronaut. Urinary calcium levels increase dramatically in space making them good potential markers for bone loss and kidney stone risk. Calcium concentrations from the Skylab mission increased 2-to-4-fold relative to preflight baselines. Clinically, 24-hour urine collections are typically used to assess urinary calcium excretion, but calcium concentration measurements taken from only the first void of the day can provide similar information. Using spot measurements, rather than 24-hour collections, could provide actionable operational information with minimal crew time, power, and stowage.

**METHODS:** We developed a small, handheld device that measures urinary calcium concentration fluorometrically using the marker calcein. Calcium binds with calcein to form a fluorescing complex. The magnitude of the fluorescence signal is proportional to the calcium concentration. The first generation assay we developed uses a compact disposable: a small capillary tube (optrode) with a fixed amount of calcein reagent coated onto the interior wall. Urine is drawn into the capillary tube which is then inserted into a compact handheld fluorimeter to measure urinary calcium concentration. Testing of our initial optrode design showed a narrow linear range (a dynamic range of 2). A wider dynamic range would reduce or eliminate the need to dilute samples to a concentration that fits within the readable linear range, and this improvement would simplify inflight sample preparation procedures. We have tested variations on the recipe to see what formulations improve the dynamic range. Testing explored the inclusion or exclusion of potassium-citrate and the use of KOH or NaOH as the buffering ingredient. **RESULTS:** The results favor the recipe using KOH with potassium citrate. This formulation has a dynamic range of 4, which is higher than the other formulations. NaOH without potassium citrate had a dynamic range of 2, KaOH without potassium citrate had a dynamic range of 2, and KaOH with potassium citrate had a dynamic range of 1.5. **DISCUSSION:** The inclusion of potassium citrate may have prevented precipitation of calcium from out of solution, leading to better results.

**Learning Objectives**

1. The audience will learn about serial first morning void sampling rather than 24-hour urine collection as a more operationally compatible method to analyze urine samples in spaceflight.
2. The audience will learn about a compact device that can enable inflight monitoring of bone loss and kidney stone risk for astronauts by spot checking urine calcium concentrations.

**[57] FLYING DUXS: DIAGNOSTIC ULTRAPORTABLE X-RAY FOR SPACE**

Sheyna Gifford<sup>1</sup>, David Lerner<sup>2</sup>

<sup>1</sup>Washington University-St. Louis, St. Louis, MO, United States; <sup>2</sup>University of Washington, Seattle, WA, United States

**(Original Research)**

**INTRODUCTION:** The only diagnostic imaging modality routinely available in microgravity is ultrasound. Prior attempts to expand imaging modalities, including the Diagnostic Radiographic Imaging System (DRIS), were unable to provide a risk-to-benefit profile supportive of deploying medical X-Ray systems in space. In this presentation, we describe how the barriers of launch mass and operational complexity were overcome using newer, ultraportable digital technology to perform the first high-quality human X-Rays in microgravity. **METHODS:** A commercial, off the shelf (COTS), ultraportable (total mass 10.3 kg), digital X-Ray system was flown on a parabolic flight through a series of microgravity intervals. Two flyers, an X-Ray technician and a physician, achieved image stability during 20-30 second microgravity intervals by utilizing a combination of positioning (seated, belted, foot- and handholds), a harness-based mounting system, and short exposure times at 90 kVp. In the first parabolic arch, images of a line phantom were taken to establish baseline image quality. Images taken during subsequent parabolas including real anatomical locations of interest to diagnoses listed in the Integrated Medical Model and the

IMPACT condition list. **RESULTS:** Review of the line phantom for spatial and contrast resolution revealed imaging capabilities in microgravity that were equal to stationary imaging systems on Earth at 1 gravity. These were considered diagnostic images qualitatively by a panel of fellowship trained radiologists. The human radiographic images were also considered diagnostic images qualitatively by a panel of fellowship trained radiologists. **DISCUSSION:** Diagnostic Ultra-portable X-Ray for Space (DUXS) experiment described here demonstrated for the first time that extant COTS technology is capable of producing medical-grade images of human beings in a microgravity environment. On Earth, this same technology is also routinely used to create high-quality images of animals and hardware during non-destructive evaluation. It has been used to image space suit components, has dental diagnostic capability, is rugged, and user-independent. Given the results of the DUXS experiment and the demands of the IMPACT condition list to rapidly and accurately diagnose an increasing number of conditions amenable to X-Ray analysis, now is the time to discuss the best paths to implementation of ultraportable X-RAY systems into near and far-term medical care beyond Earth.

#### Learning Objectives

1. Ultraportable X-ray technology addresses multiple Human Research Roadmap gaps and allows for clear diagnosis of many of the Integrated Medical Model and IMPACT list medical conditions including at least seventeen conditions that can only be diagnosed by X-Ray, such as dental caries/abscess, stress fractures, and acute sinusitis.
2. Newer advances in X-ray imaging capability allow the realistic possibility of diagnostic x-rays for human, animal, and non-destructive component evaluation in microgravity.

#### [58] FLEXIBLE MACHINE LEARNING PIPELINE FOR THE PREDICTION OF TACHYCARDIA FOR DEEP-SPACE MEDICAL MONITORING.

Cyril Mani<sup>1</sup>, Tanya Sarah Paul<sup>2</sup>, Alexandre Marois<sup>2</sup>

<sup>1</sup>McGill University, Montreal, PQ, Canada; <sup>2</sup>Thales Research and Technology Canada, Quebec City, PQ, Canada

#### (Original Research)

**INTRODUCTION:** Deep-space missions restrict the ability of ground resources to assist crews in need of medical attention. One solution is to empower the crew directly with on-board health monitoring capacities. This enables preventative care relying on predictive models and health data for anticipating or detecting in-space pathologies. Deploying such models requires flexible edge computing, which Open Neural Network Exchange (ONNX) formats could optimize by enabling inference directly on flight-proven wearable computing devices. This work demonstrates the performance of an ONNX machine-learning model pipeline which recognises periods of normal sinus rhythm (NSR), atrial fibrillation (AFIB) and atrial flutter (AFL) and from a 2-lead ECG wearable. **METHODS:** Over 563 hours of ECG recordings from diverse patients were used to train and test a supervised multinomial regression model. The data was pre-processed into 30-s normalized and denoised strips where self-adjustable variable mode decomposition removed muscle artifacts and electro-surgical noise. Then, 17 heart rate variability and morphological ECG features were extracted by convoluting peak detection with Gaussian distributions - for probabilistic peak locations - and by delineating QRS complexes using discrete wavelet transforms. Models based on rotated ECG features and hyperparameters were 10-fold cross-validated against cardiologist labelling of the ECG recordings and compared with F-1 scoring. **RESULTS:** The selected model had a mean F-1 score of 0.88 with specific scores of 0.95 for NSR, 0.92 for AFIB and 0.76 for AFL. It attributed most weight ( $\beta$ ) to the following features: median P amplitude (0.71), PNN20 (0.12), mean heart rate (0.08), maximum heart rate (0.03), SDNN (0.02), PNN50 (0.01), median S amplitude (0.01) and SDSD (0.01). The ONNX-adapted ECG pipeline from raw sliding window to prediction took 9.2 s per strip. **DISCUSSION:** The model based on morphological and high-impact computed signal features demonstrated accurate detection of tachycardia with lower identification of AFL compared to AFIB and NSR. The multivariable deterministic predictions can support on-board

medical officers with constant monitoring of the crew's health to prioritise resource allocation when tachycardia patterns are detected. Using the ONNX format, future pipeline iterations can be easily adjusted to other types of tachycardia to help further understand microgravity-induced cardiovascular degradation.

#### Learning Objectives

1. The audience will be able to visualize the working steps of a whole machine learning model pipeline and understand its quantitative capacity to recognize atrial fibrillation, atrial flutter and normal sinus rhythm from biomonitoring ECG wearable data streams.
2. The audience will learn about methodologies to denoise for muscle artifacts, power supply interference and electrosurgical noise common in wearable ECG data taken in analog spacecraft environments.
3. The audience will understand the use cases of a real time multivariable cardiovascular predictive model in assisting the on-board medical officer of a deep space mission. In addition, they will learn about the advantages of ONNX-adapted models in such use cases.

#### [59] NON INVASIVE VENTILATION EVALUATION FOR EXPLORATION MISSIONS

Aaliya Burza<sup>1</sup>, Christopher Haas<sup>2</sup>, David Alexander<sup>2</sup>

<sup>1</sup>SUNY Downstate Health Sciences University, Brooklyn, NY, United States;

<sup>2</sup>NASA JSC, Houston, TX, United States

#### (Education - Tutorial/Review)

**INTRODUCTION:** This session will review the evidence supporting the use of non-invasive ventilation (NIV) for acute respiratory failure and will evaluate the validity and viability of using various modalities of NIV within the mass and volume constraints of exploration missions. **TOPIC:** NIV is the delivery of ventilatory support or positive pressure into the lungs without an invasive endotracheal airway, usually through a mask. The use of NIV for acute respiratory failure has rapidly increased over time and observational and meta-analysis studies have demonstrated a trend towards lower intubation rates when used early during respiratory failure. **APPLICATION:** Potential NIV devices that can provide noninvasive ventilation include continuous positive airway pressure (CPAP) devices used for obstructive sleep apnea and some transport ventilators. These devices can deliver the oxygen, positive end expiratory pressure (PEEP), and minute ventilation needed by the patient while matching the increased demand flow rates that can occur during acute respiratory failure. Using a travel CPAP and transport vent can further make them adaptable to spaceflight given the small mass and volume footprint of these devices. Emerging developments in high flow nasal cannula (HFNC) have opened the possibility to use HFNC as an NIV device and may also be considered. While some devices will be more easily integrated into exploration vehicles, all devices currently available will need some modifications to be spaceflight ready. Regardless, it is important to understand how the latest evidence supports the use of NIV early for acute respiratory failure in exploration missions and can also lead to more rapid improvement of physiological variables and a reduction in the need for invasive mechanical ventilation.

#### Learning Objectives

1. The audience will learn about the evidence supporting the use of Non invasive ventilation (NIV) in acute respiratory failure.
2. The audience will also learn about the various types of NIV devices available that can be potentially considered to be used during the flight.

#### [60] DERIVING AN OPTIMIZED ANTIMICROBIAL KIT FOR NASA'S ACCEPTED MEDICAL CONDITION LIST

Jose Castillo-Mancilla, Arian Anderson

University of Colorado, Aurora, CO, United States

#### (Education - Program/Process Review)

**BACKGROUND:** Medical care aboard the International Space Station (ISS) benefits from habitable volume and proximity to earth and allows for a relatively large medical kit. With upcoming deep

space missions however, the paradigm for medical system design will change to substantially minimize mass and volume. Infectious diseases are among the largest contributors to medical risk in spaceflight and represent nearly ¼ of NASA's updated Medical Condition list. Therefore, optimizing a robust but minimalistic kit for exploration spaceflight presents an important challenge. We aim to use antibiogram data in conjunction with NASA's condition list and known constraints of the spaceflight environment to derive an optimized antimicrobial kit.

**OVERVIEW:** NASA's 120 Accepted Medical Conditions were filtered to select conditions resulting from infectious disease ranked by risk of death. The University of Colorado Hospital (UCH) antibiogram was then overlaid with these conditions to create a rank of antibiotics for treatment of each condition. Antibiotic spectrum, including Methicillin-resistance *Staphylococcus aureus* (MRSA) and *Pseudomonas aeruginosa* was included based on prior spaceflight data. Each antibiotic was assigned a score based on effect size, utility in spaceflight, and resource requirement for both outpatient (mild) and inpatient (severe) treatments and collated to a total value score. 29 of 120 conditions were identified as involving infectious etiologies and 30 antibiotics were considered based on the UCH antibiogram. After considering spectrum, oral bioavailability, possibility of parenteral dosing and tolerability, the most valuable outpatient antibiotics included oral levofloxacin and linezolid and inpatient included intramuscular (IM) ceftriaxone and cefepime. **DISCUSSION:** Our methodology identified a limited number of outpatient and inpatient antibiotics that combine to a small formulary that can cover all infectious disease conditions included on NASA's medical condition list. An antimicrobial kit including oral levofloxacin oral linezolid, ceftriaxone (IM), and cefepime (IM) can treat all infectious conditions of concern. If excluding antibiotic stewardship and the kit can be further reduced in size but increases risk of resistance. Inclusion of fluconazole and valacyclovir creates the most complete and optimized medical kit needed to treat all infectious disease related conditions impacting medical risk in spaceflight.

#### Learning Objectives

1. Understand the constraints of a medical system for exploration class missions to deep space.
2. Demonstrate how antibiogram data can be used with a medical condition list to identify organisms that most contribute to medical risk.
3. Use the list of infectious organisms to derive an optimized antimicrobial kit.

#### [61] PROCEDURAL MEDICINE PRACTICALITIES FOR SPACEFLIGHT

Dana Levin<sup>1</sup>, Tovy Kamine<sup>2</sup>

<sup>1</sup>Baylor College of Medicine, Houston, TX, United States; <sup>2</sup>Baystate Medical Center, Springfield, MA, United States

(Education - Program/Process Review)

**BACKGROUND:** Medical planning for exploration class missions may require a higher level of procedural skill than has been available on spacecraft to date. NASA's updated conditions list for exploration missions from the Human Research Program's Exploration Medical Capability Element includes several conditions that reflect this. While it is unlikely that spacecraft will support or require fully invasive surgical capability in the foreseeable future, there are many procedures that may be required to treat these conditions that are potentially practical in the spaceflight environment. **DESCRIPTION:** Subject matter experts (SMEs) in procedural medicine and space medicine were assembled to discuss procedures that may be required to treat the conditions on NASA's IMPACT Conditions List. The SMEs evaluated each procedure according to necessity, alternatives, chance of a successful outcome, requirements of post procedural management, recovery time, and practicality in the spaceflight environment. **DISCUSSION:** The resultant list of procedures represents a potential component of future space medical officer training to ensure safety of flight.

#### Learning Objectives

1. Understand that procedural training will likely be needed by CMOs on exploration missions.
2. Understand that many procedures are not practical in spaceflight and will need to be modified or will not be possible.
3. Describe a method by which practical procedures can be identified to develop effective training.

Monday, 05/22/2023

2:00 PM

Grand Ballroom D-E

#### [S-12]: SLIDES: COVID-19 & HISTORY... POTPOURRI

Chair: Kristian Mears

Co-Chair: Denise Baisden

#### [62] CHALLENGE OF COVID-19 VACCINE MEDICAL EXEMPTION IN A MILITARY PILOT AFTER BELL'S Palsy

Jianzhong Zhang<sup>1</sup>, Sarah Madden<sup>2</sup>

<sup>1</sup>55th Medical Group, Offutt AFB, NE, United States; <sup>2</sup>55th Operation Group, Offutt AFB, NE, United States

(Education - Case Study)

**INTRODUCTION:** An active-duty RC-135 pilot developed Bell's palsy after COVID-19 infection. After full recovery he was returned to flying status. Due to the strong association of COVID-19 infection with the development of the Bell's palsy. The member is hesitant to be vaccinated and applies for medical exemption, which if granted, will help him to stay in military service. If vaccinated he is at high risk to develop further Bell's palsy symptoms which will result in him losing his military and civilian aviation career. **BACKGROUND:** Bell's palsy is not life threatening but can be a career eliminating disease in military aviation service. Literature review indicates that people infected with COVID-19 have a higher risk to develop Bell's palsy. It is possible that the virus or antibody to COVID-19 is responsible for causing Bell's palsy. If so, should medical exemption be granted? The answers are complicated and are discussed below. **CASE PRESENTATION:** A 34 y.o. male pilot comes in the clinic to discuss potential issues of receiving COVID-19 vaccine exemption due to the fact that he contracted Bell's palsy 3 weeks after being diagnosed with COVID-19 infection. He notes weakness in the right lower face especially with laughing and smiling. He reports some aberrant regeneration with crocodile tears when eating and also closure of right eye when smiling, and he cannot raise his right forehead fully. He was diagnosed on 30 Dec 2020 with moderate to severe Bell's Palsy (a House-Brackmann facial paralysis score of 5) and was started on Prednisone 60mg/day and Valtrex 1gm bid x 7 days. At his follow up appointment on 9 March 2021 it was documented that he improved (recovered about 70%) with residual symptoms (some facial weakness). His symptoms were near completely resolved and he was returned to flight status with a waiver on 18 May 21. It took more than a year for him to get medical exemption on 22 Sept 22. **DISCUSSION:** Member seems to have a clear viral infection related to nervous system disorder. In a given year and virus, the medical recommendation to not vaccinate should be straight forward. However, given the unprecedented world-wide health concern caused by COVID-19, the medical exemption process took time and insight. After returned to duty, his unwillingness to be vaccinated put him in danger of losing his career. With the improvement of population immunity, treatment options and understanding of the virus, he received medical exemption.

#### Learning Objectives

1. The participant will be able to make appropriate vaccine medical exemption recommendations for those who have a medical condition

that could cause an adverse reaction if vaccinated, the risk may outweigh the benefit.

2. The participant will be able to understand, that unvaccinated people may spread the virus if infected, it is important to balance the individual desire and the need of general population health protection.
3. The audience will learn that Bell's palsy can be a complication of COVID-19 infection.

### [63] CLINICAL CHARACTERIZATION OF MEDICAL CERTIFICATE HOLDERS WITH CONFIRMED SARS-COV-2 INFECTION REPORTED TO THE CIVIL AVIATION AUTHORITY OF COLOMBIA

Laura Maria Pineda Jimenez<sup>1</sup>, Johana Giraldo Alzate<sup>2</sup>, Maria Angelita Salamanca Benavides<sup>2</sup>, Alexandra Mejia Delgado<sup>2</sup>, Patricia Barrientos<sup>2</sup>, Diego Manuel Garcia Morales<sup>3</sup>

<sup>1</sup>National University of Colombia, Bogota, Colombia; <sup>2</sup>Civil Aviation Authority of Colombia, Bogota, Colombia; <sup>3</sup>Embry-Riddle Aeronautical University, Daytona, FL, United States

(Original Research)

**INTRODUCTION:** The burden of the COVID-19 pandemic in working populations is still unknown. Safety-critical populations, such as aeromedical certificate holders, should be monitored to assess type, severity, and sequelae after the infection by Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2). The present study aimed to describe the clinical characteristics of medical certificate holders with confirmed SARS-CoV-2 infection reported to the Civil Aviation Authority of Colombia (CAAC), 2020-2021. **METHODS:** Retrospective observational study on medical certificate holders with confirmed SARS-CoV-2 infection who reported their condition to the CAAC and sent their medical records. Patient data was manually abstracted and exported to Microsoft Excel® (Office 2016). **RESULTS:** CAAC counts 14,089 aeromedical certificate holders, of which 679 (4.8%) reported for SARS-CoV-2 infection. Of those, 332 (48.8%) submitted complete data of their event, mostly men 206 (62.04%), mean age 38.29 years (SD 10.9), of which 87 (26.20%) were asymptomatic, 211 (63.55%) presented with mild, 28 (8.43%) with severe and 6 (1.80%) with critical infection. Three certificate holders (0.9%) were reported deceased. Most frequently reported symptoms were respiratory 213 (64.1%), comprising dry cough 137 (41.2%), odynophagia 125 (37.6%), rhinorrhea 114 (34.3%) and dyspnea 69 (20.7%); followed by general symptoms (197, 59.3%), such as adynamia 119 (35.8%), malaise 117 (35.2%), and fever (82, 24.6%); 149 (44.8%) reported neurological symptoms, including headache 111 (33.4%), dyssomnia 83 (25%) and 64 dysgeusia (19.2%). Finally, most complications were respiratory 38 (11.4%), including mild 29 (8.7%) and severe pneumonia 9 (2.7%) and infectious complications 10 (3%), such as bacterial superinfection, sepsis, and septic shock (2.1%, 1.5%, and 1.2% respectively). **DISCUSSION:** Clinical characteristics of SARS-CoV-2 infections in Colombian aeromedical certificate holders are similar to those reported in the literature for general populations, the long-term effects of this affectionation is still being assessed. Knowing clinical characteristics of COVID-19 infections in this high-impact population will inform future actions, programs and policies for assuring top human performance in their safety-critical roles, and to improve certification decision-making processes.

#### Learning Objectives

1. The audience will be able to compare the frequency of SARS-CoV-2 infection during the pandemic (2020-2021) in medical certificate holders from the Civil Aviation Authority of Colombia with the published literature.
2. The audience will be able to go over the most frequent symptoms and complications of the SARS-CoV-2 infection in medical certificate holders during the pandemic (2020-2021) from the Civil Aviation Authority of Colombia.

### [64] SPACE TECHNOLOGY AND THE MANAGEMENT OF PUBLIC HEALTH DISASTER: COVID-19 PANDEMIC AS A CASE STUDY IN THE MIDDLE EAST FOR IMPROVED PREPAREDNESS.

Ahmed Baraka<sup>1</sup>, Anthony Yuen<sup>2</sup>, Clara Moriceau<sup>3</sup>

<sup>1</sup>Alexandria University, Shoubra Khit, Egypt; <sup>2</sup>Space Generation Advisory Council, New York, NY, United States; <sup>3</sup>Medes Institute for Space Medicine and Physiology, Toulouse, France

(Education - Program/Process Review)

Responding to public health disasters such as the COVID-19 pandemic is challenging and such pandemics might become more frequent in the future. Space technology can play an important role to support responses to public health disasters. Use cases of space technologies for terrestrial health include data and imagery from Earth Observation and remote sensing satellites, advanced communication supporting telemedicine applications from LEO constellations, and global positioning information. Increasing the role of space technology to support such a response is a must for better control and readiness for any possible future pandemics. Countries in the Middle East can implement such technologies in preparation for future pandemics. Based on recent experiences from the COVID-19 pandemic, we will focus on such responses in UAE, Israel, and Saudi Arabia as examples in the Middle East region and compare that with the other countries like the US, China, and the EU. In conclusion, we aim to highlight the lessons learned and the best strategies that could be implemented in countries in the Middle East for any future pandemics to make sure that all the countries can successfully control the spread of such contagious diseases in the future.

#### Learning Objectives

1. Assessing the response of the Middle Eastern countries to COVID-19 as a pandemic and how they applied space technology to the management of this public health disaster.
2. A comparison with other countries outside the Middle East describes the best practices that the Middle Eastern countries should follow and adapt to handle any future possible public health disaster using the available resources of the space assets.

### [65] RISK ASSESSMENT FOR MEDICAL CERTIFICATION IN PREGNANCY - AN AUSTRALIAN MODEL

Kate Manderson

CASA Australia, Canberra, Australia

(Education - Program/Process Review)

**BACKGROUND:** ICAO Standards for medical certification state that flying and controlling duties during pregnancy must be ceased from 28 weeks' gestation. At the same time, individual states retain the ability to assess individual cases with an accredited medical conclusion process.

**OVERVIEW:** Australia has historically applied a uniform approach of suspension of flying for private and commercial pilots from 30 weeks gestation, while controllers may continue with weekly review up to 38 weeks. With a move towards certification using less restrictive standards for flying, such as those for motor vehicle licenses, we are now exploring a risk-informed approach to allowing pilots to continue flying beyond 30 weeks gestation. **DISCUSSION:** We present a review of the current Australian data on high-risk pregnancy and pregnancy outcomes, and a proposed model for periodic review for pregnancies at lower risk. This approach will enable those pilots who wish to continue flying while pregnant to choose to do so, whether commercially or privately.

#### Learning Objectives

1. The participant will be able to consider the features of normal and high-risk pregnancies that present aeromedical risk.
2. The audience will learn about an approach to a collaborative approach to ongoing aviation risk assessment for pregnant pilots.
3. The participant will be able to plan an evidence-based risk assessment process for their pregnant pilots.

## [66] THE FARNSWORTH F2 TRITAN PLATE: THE BEST EVER CONGENITAL RED/GREEN COLOR VISION (CV) SCREENING PSEUDOISCHROMATIC PLATE (PIP) TEST?

Douglas Ivan<sup>1</sup>, Ben Lawson<sup>2</sup>, Adrien Ivan<sup>3</sup>, Jeffery Hovis<sup>4</sup>

<sup>1</sup>ADI Consultants, San Antonio, TX, United States; <sup>2</sup>Naval Submarine Medical Research Lab, Naval Submarine Base New London, Groton, CT, United States;

<sup>3</sup>Vernon College, Wichita Falls, TX, United States; <sup>4</sup>University of Waterloo, Waterloo, ONT, Canada

(Education - Tutorial/Review)

**BACKGROUND:** The epicenter for US Navy color vision (CV) research during and for several decades after WWII was the Naval Medical Research Laboratory (NMRL), eventually the Naval Submarine Medical Research Laboratory (NSMRL), at the U.S. Naval Submarine Base New London in Groton, Connecticut. Vision research activities at New London were greatly enhanced by the assignment of Dean Farnsworth to active duty in 1943, transitioning remarkably from his research-associated activities within his post-graduate theatrical arts studies at New York University (NYU). Numerous CV testing devices evolved during his tenure at the NSMRL, most notably the Farnsworth Lantern (FaLant), which remains an integral part of military and civilian aviation CV screening methodologies to this very day. **OVERVIEW:** One of the lesser-known devices Farnsworth developed and produced at NSMRL was his F2 Tritan (blue/yellow) CV screening test plate (a follow-on to his F1 polychromatic plate depicted in a 1951 edition of *Picture Post* magazine) to help determine the incidence of blue/yellow CV deficits within the general United Kingdom (UK) population. Surprisingly, the F2 plate also became a widely acclaimed congenital red/green CV screening test based on its color-confusion design. It became an integral part of the pseudoisochromatic plate (PIP) four-test battery employed in the USAF's Enhanced/Medical Flight Screening (EFS/MFS) Program for pilot candidate selection, once it became obvious that traditional single-edition CV PIP tests were compromised by widely known cheating scams. There were also new mission requirements and policy directives that demanded normal CV (red/green and blue/yellow) in future USAF pilot selectees. **DISCUSSION:** This paper will present historical background details about F2 plate design developments recently uncovered in archival NSMRL materials. We will also present historical comparisons about its effectiveness as a congenital red/green CV screening device, compared to the Dvorine and the Standard Pseudoisochromatic Plates (SPP I/SPP II tests), within a novice USAF pilot candidate pool undergoing EFS/MFS CV screenings. (The views in this presentation represent those of the authors and not the U.S. government nor its agencies. No U.S. Government endorsements are implied; Copyright protection not implied.)

### Learning Objectives

1. The audience will learn about the legacy of the significant color vision testing contributions from Dean Farnsworth and his staff at the US Navy Submarine Medical Research Laboratory during and after World War II.
2. Attendees will learn about the history and design issues related to blue/yellow color vision testing and the effectiveness of the Farnsworth F2 Tritan color vision test plate.

## [67] WORLD WAR I BRITISH FLYING ACE EXTRAORDINAIRE, MAJOR EDWARD "MICK" MANNOCK, VC, DSO, MC: DID HE REALLY HAVE ONLY ONE GOOD EYE?

Adrien Ivan<sup>1</sup>, Douglas Ivan<sup>2</sup>, Thomas Tredici (Posthumously)<sup>3</sup>

<sup>1</sup>Vernon College, Wichita Falls, TX, United States; <sup>2</sup>ADI Consultants, San Antonio, TX, United States; <sup>3</sup>University of Texas Health Sciences, San Antonio, TX, United States

(Education - Tutorial/Review)

How much depth perception capability is needed, particularly binocularly derived spatial awareness (stereopsis), to be a successful aviator has remained under perpetual debate ever since World War I (WWI). Good binocular function was continuously aggravated by additional stressors

associated with combat operations of the day, including long periods of time at hypoxic altitudes without supplemental oxygen, the Oxygen Paradox, unrestrained flight hours, extreme fatigue, and psychasthenia. Compounding the problem was the general attitude amongst period pilots that facing such adversity was sport, a challenge to be met head-on without complaint. Field studies and laboratory investigations during WWI almost universally supported the need for good ocular muscle control, particularly to avoid double-vision or loss of stereopsis. Vision experts of that period on both sides of the conflict were absolutely convinced that pilots needed normal stereopsis to survive flying training and aerial combat. With rare exception, it is difficult to argue that two normal eyes are much better than one, especially when trying to avoid injury and stay alive. Nonetheless, a few notable exceptions to that premise emerged during WWI, often used to challenge that two normally functioning eyeballs might not necessarily be an absolute requisite. Two of the more well-known "exceptions," who later became combat aces, were American William "Bill" Thaw II with 5 confirmed aerial kills (possibly 7) and British ace Edward "Mick" Mannock with possibly 73 total enemy kills (61 confirmed/12 unconfirmed). Of the two, it was Mannock who was far more productive in terms of aerial warfighting tallies and nicknamed the "One-Eyed Ace." In reality, neither of these individuals was actually one-eyed, but each was thought to have impaired vision in one eye. However, some historians have recently challenged whether Mannock, in particular, had any persistent eye problem at all and that his boastful claim to have memorized the visual acuity test chart to avoid detection of a poorly seeing eye during his medical examinations may not have been accurate. This presentation will explore the available records and events, including Mannock's own diary entries, to help determine whether he had enough of an eye problem to warrant the "one-eyed" moniker, or that possibly, he may not have had any significant eye affliction at all.

### Learning Objectives

1. The audience will learn about the pertinent historical background of the extraordinarily successful British World War I Ace, Major Edward Mannock, often labelled "The One-Eyed Ace," and the role that a longstanding eye problem may or may not have played in his aviation career.
2. The audience will learn about binocular function in the early days of combat flying and its role in vision performance in aerial dog-fighting during World War I.

**Monday, 05/22/2023**  
**Grand Chenier**

**2:00 PM**

## [S-13]: SLIDES: SAFETY & SURVIVABILITY: WHAT WENT WRONG

**Chair: Barry Shender**

**Co-Chair: Hadley Sulpizio**

## [68] FLYING BLIND? INVESTIGATING GLAUCOMA IN A FATAL MIDAIR COLLISION

Turan Kayagil

NTSB, Washington, DC, United States

(Education - Case Study)

**INTRODUCTION:** On the morning of July 31, 2020, a chartered de Havilland DHC-2 Beaver and a Piper PA-12 were destroyed in a midair collision near Soldotna, Alaska, fatally injuring both pilots and all five Beaver passengers. The investigation by the United States National Transportation Safety Board (NTSB) discovered that the Piper pilot had been denied aeromedical certification due to open-angle glaucoma. Investigating whether this condition contributed to the crash required collaboration among NTSB experts to interpret and connect medical and non-medical evidence. **BACKGROUND:** The NTSB is an independent United States government agency that investigates all domestic civil

aviation accidents with the goal of making recommendations to improve safety. Open-angle glaucoma is a condition that has potential to impair pilot performance insidiously, as optic nerve damage may progress unnoticed for years, with irreversible visual field loss. Decreased contrast sensitivity and increased susceptibility to glare may also pose hazards to pilots with glaucoma. **CASE PRESENTATION:** The NTSB medical investigation of the Piper pilot reviewed evidence including toxicology and autopsy reports, aeromedical certification records, personal medical records, and records from a commercial driver medical examination. Ophthalmology and optometry records, including reports from automated visual field testing, showed that the pilot had severe visual field defects in both eyes, with controlled intraocular pressures and good results on visual acuity testing. The NTSB medical officer worked with agency experts in human performance and crash reconstruction to develop an understanding of how the pilot's disease may have affected his interactions with his visual environment before the collision. **DISCUSSION:** The investigating NTSB medical officer will present this case in context of the agency's medical investigation process and will discuss aeromedical aspects of open-angle glaucoma.

#### Learning Objectives

1. Develop awareness of how the United States National Transportation Safety Board evaluates potentially impairing pilot medical conditions in crash investigations.
2. Review how open-angle glaucoma is assessed and how it can affect pilots.

#### [69] FAST JET HEAD INJURY BIOMECHANICS

Alasdair Mackay<sup>1</sup>, Mazdak Ghajari<sup>2</sup>

<sup>1</sup>RAF, Henlow, United Kingdom; <sup>2</sup>Imperial College, London, United Kingdom

#### (Original Research)

**INTRODUCTION:** In the UK, military aircrew helmets are required to meet the Military Aircrew Helmet Impact Standard (MAHIS). This standard requires a helmeted headform to be dropped onto a metal anvil from a prescribed height, measuring the accelerations transmitted to accelerometers within the headform. The pass/fail threshold for MAHIS is a translational (linear) acceleration of 300G when impacting a flat or hemispherical anvil at 6 m/s. Translational injury protection has been shown to reduce the risk of frontal bone fracture, but its ability to reduce the risk of specific intracerebral pathologies is less well established. There is a growing scientific body of evidence that protection against rotational acceleration reduces the risk of the several brain pathologies, especially concussion, loss of consciousness and diffuse axonal injury. Internationally, several helmet impact standards now require helmets to pass a rotational threshold. To understand the risk of head injury faced by aircrew, this research aims to identify the types and severity of head injuries sustained during fast jet ejections. **METHODS:** A review of the ejection database held at the RAF Centre of Aviation Medicine from 1975 to the present day was completed. For each ejection, information was collected on the incidence of head injury, any pathological findings, and the mechanism of injury. **RESULTS:** There have been 268 fast jet ejections since 1975. 27 cases of significant brain injury were identified; these consisted of either a loss of consciousness or concussion lasting less than 20 minutes. There were no cases of skull fractures or significant intracerebral pathologies resulting from "in envelope" ejections. **DISCUSSION:** MAHIS requires that helmets demonstrate translational impact protection and yet there have not been any cases of pathology associated with this mechanism; this may be an indication that aircrew helmets are adequately protecting against translational impacts. This review provides evidence of the potential contribution of rotational acceleration to head injuries in aircrew. Unlike several international helmet standards, these are not currently accounted for in aircrew specific helmet standards. Even a brief loss of consciousness is a risk to life for aircrew ejecting over water, in a conflict zone or when parachute landing onto aircraft wreckage. A review of aircrew helmet impact standards is encouraged to ensure the risk of head injury is being adequately mitigated.

#### Learning Objectives

1. Understand that rotational acceleration is an important factor in the etiology of traumatic brain injury.
2. Learn about the common brain injuries sustained during ejection from a fast jet aircraft.

#### [70] MOLECULAR ASSESSMENT OF CARDIOVASCULAR PATHOLOGY IN AIRCRAFT ACCIDENT INVESTIGATION - STRATEGIES AND LIMITATIONS WITH A FOCUS ON MICRO-RNA ANALYSIS

Michael Schwerer

Air Force Centre of Aerospace Medicine, Cologne, Germany

#### (Original Research)

**INTRODUCTION:** Recognizing pathologic conditions in the heart of an aircraft accident victim can be challenging in autopsy and histology. Blunt or sharp force trauma, fire and/or decomposition frequently impair morphological examination. Studying molecular markers could be an alternative approach less prone to pre-mortem or post-mortem tissue changes. MicroRNA (miRNA) analysis could provide insight into a decedent's myocardial condition at the moment of the mishap. **METHODS:** Our current study involves left ventricular wall samples from aircraft accident victims along with control specimens from hospital patients which died from cardiovascular disease. The possibilities and limitations of molecular heart pathology are investigated. For this, automated RNA preparation is carried out using the Maxwell16<sup>®</sup> System (Promega, Mannheim, Germany). Semiquantitative demonstration of miRNAs employs the miScript<sup>®</sup> Technology (Qiagen, Hilden, Germany) and the 2<sup>-ΔΔCt</sup> method. The first round of assessment presented here is based on eight decedents, four of them military pilots, the others heart disease casualties. MicroRNA-133a and -208b were evaluated with SNORD95 used as a reference. **RESULTS:** Between 2.6- to 6-fold (1.2- to 7.5-fold) increases in the expression of miRNA-133a (miRNA-208b) were detected in the myocardium of three military jet aviators compared to an army helicopter pilot. The control samples from heart disease patients revealed variable expression rates of miRNA-133a and -208b. Up-regulation of miRNA-133a was not observed in this group, whereas a subset of cases with significant myocardial necrosis and remodeling demonstrated 3.6- to 5.9-fold increases in miRNA-208b expression. **DISCUSSION:** These preliminary data reveal an increased expression of the myocardium-specific regulatory miRNA-133a along with miRNA-208b in military jet flyers. A previously unrecognized adjustment pattern to the physiological burdens of their type of aviation must be discussed. Up-regulation of miRNA-208b, an established marker for myocardial injury and repair in clinical patients, must not be misinterpreted for pre-existing disease in military jet pilots killed in aircraft accidents. Putatively, additional investigations will further recommend molecular pathology as a powerful tool in aviation medicine and pathology.

#### Learning Objectives

1. Knowing the limited value of autopsy and histology in aircraft accident victims.
2. Learning about the potential of molecular diagnostics in aeromedical practice.

#### [71] SUSPECTED HYPOXIA-LIKE PHYSIOLOGICAL EPISODES IN ADF 1990-2020: A SYSTEMATIC ASSESSMENT OF AIRCREW RESPONSE TO SUSPECTED HYPOXIA IN FLIGHT

Adrian Smith

RAAF Institute of Aviation Medicine, Adelaide, Australia

#### (Original Research)

**INTRODUCTION:** Hypoxia-like physiological episodes (PHYSEPs) remain a significant concern for military aircrew, especially those operating high-performance aircraft. Optimal response to a PHYSEP requires crewmembers to be aware of symptoms, recognize the significance and decide to act, correctly execute checklist actions in a timely manner, and

use their emergency equipment effectively. This study characterized aircrew response to suspected hypoxia to understand the impact of practical hypoxia training in shaping their behavior. **METHODS:** Australian Defence Force aviation safety reports were interrogated to identify 127 events in which aircrew reported 'hypoxia-like symptoms'. These events underwent a systematic assessment and classification. **RESULTS:** Awareness of symptoms was the trigger for aircrew response in only 54.3% of events; the remaining events involved symptoms after an aircraft warning (16.6%), a smell (7.9%), degraded performance (5.5%), or resistance to breathing (4.7%). The most-commonly reported symptoms were lightheadedness (30%), hot flush (28%), tingling of fingers or lips (19%), and confusion (14%); 39.4% of events described a hyperventilation-like syndrome. Hypoxia was the most-credible explanation in 48.1% of events, with others attributed to hyperventilation-like syndrome (14.2%), or 'critical event response' (11.8%). Although 27.6% of safety reports were complimentary of the value of hypoxia training, 39% were critical of hypoxia training in the recognition of and response to suspected hypoxia, in particular decision-making (44%), checklist discipline (31.5%), familiarity with and use of life-support equipment (29.1%). These issues complicated the PHYSEP in a significant proportion of events (29.1%). **DISCUSSION:** Aircrew response to unusual symptoms in flight requires a complex interaction of awareness of symptoms, decision-making, checklist discipline, and familiarity with life-support equipment. Traditional aeromedical training focuses of symptom awareness rather than response to symptoms. This study shows that lack of awareness of symptoms is not a primary consideration in hypoxia-like PHYSEPs, and that flawed response in aircrew who are aware of symptoms and suspect hypoxia can complicate a PHYSEP. **CONCLUSION:** Aircrew training should consider strategies to promote timely and effective recovery actions in addition to hypoxia 'awareness' experiences.

#### Learning Objectives

1. The audience will learn about the way aircrew respond to PHYSEPs in real-world scenarios.
2. The audience will learn about the importance of focusing aeromedical training on shaping aircrew response to PHYSEPs rather than symptom awareness.

### [72] SURVIVAL AFTER DITCHING IN MOTORIZED AIRCRAFT – ANALYSIS OF THE NTSB DATABASE (1989-2022)

Jochen Hinkelbein<sup>1</sup>, Volker Schick<sup>1</sup>, Douglas Boyd<sup>2</sup>,  
Catherina Hippler<sup>1</sup>

<sup>1</sup>University Hospital of Cologne, Cologne, Germany; <sup>2</sup>No affiliation, Houston, TX, United States

#### (Original Research)

**BACKGROUND:** Ditching is a rare event and has not yet been systematically analyzed for General Aviation. The aim of the present study is to investigate ditching events and survival after ditching and their possible influencing factors. **MATERIAL AND METHODS:** Descriptive analysis of ditchings. Ditchings (1982-2022) in the United States were identified from the National Transportation Safety Board (NTSB) database. Occupant injury severity definitions per 14CFR 830.2 and accompanying factors including aircraft type, pilots flight experience, flight conditions and number of occupants and flight crew members were extracted. **RESULTS:** A total of 96 ditchings were identified under 14CFR 91 and 135 flight regulations. After detailed screening, 77 ditchings could be included in the analysis. Fatal injuries occurred in 26 (33.8%) of the reported flights. In total, 128 out of 169 (75.7%) occupants survived ditching and were rescued. Passengers were fatally affected more often (passengers 29.1% vs. flight crew 19.2%,  $p=0.08$ ). The primary ditching event was survived by 94.7% of all occupants. Thirty (19%) occupants died secondarily after the ditching by drowning, hypothermia or unknown reasons. Information of life jackets are only provided in 22 (28.6%) of all reports. In these cases, life jackets were inadequately worn in 31.8% and not worn in 36.4%.

**DISCUSSION:** The primary survival after an emergency ditching is high. External factors reduced overall survival in our study population to

75.7%. A possible influence of injuries from the water impact cannot be estimated. Missing data due to unobserved events, missing bodies and lack of their forensic investigation complicated the analysis.

#### Learning Objectives

1. Learn the causes of ditchings for General Aviation accidents (engine problems, run out of fuel etc).
2. Survivability after ditchings is usually quite high but decreases due to secondary factors.
3. Risk factors during ditching.

### [73] SEDATING ANTIHISTAMINE USE IN GENERAL AVIATION ACCIDENTS: CASE REPORT AND TRENDS

Michelle Watters

NTSB, Washington, DC, United States

#### (Education - Case Study)

**INTRODUCTION:** This case report describes a general aviation accident where the probable cause was related to impairing effects of a non-prescription sedating antihistamine. **BACKGROUND:** The NTSB is charged by Congress with investigating every civil aviation accident in the US. Evaluation for pilot impairment typically includes interpretation of toxicology testing performed by the FAA Forensic Sciences Laboratory. Prior NTSB safety research studies on toxicology results for fatally injured pilots in the US have shown an increasing trend in the use of potentially impairing drugs. During 2013 through 2017, sedating antihistamines continued to be the largest category of potentially impairing drugs, with 11.9% of study pilots testing positive. Safety recommendations directed to FAA by NTSB have resulted in FAA publishing a safety briefing on antihistamines and guidance on how to evaluate over the counter medications for flying, including antihistamines. However, the NTSB continues to investigate accidents in which sedating antihistamines are identified as contributing. **CASE PRESENTATION:** In July 2020, a Cessna was substantially damaged when it was involved in an accident near Dustin, Oklahoma. The pilot who was performing aerial agricultural applications in his own aircraft was fatally injured. After taking on a load of herbicide, the airplane began its takeoff run, crested a hill, and impacted a power pole. The 62-year-old pilot held an FAA 2<sup>nd</sup> class medical certificate and had 17,100 total flight hours. Toxicology testing detected diphenhydramine at a high level in the pilot's blood. In the probable cause, the NTSB final report cited the pilot's likely diminished reaction time and flying performance due to effects of diphenhydramine. **DISCUSSION:** Potentially impairing non-prescription medications, such as sedating antihistamines, continue to represent a potential safety hazard in US aviation. In this accident, a pilot with years of experience and familiarity with his aircraft was fatally injured when using a sedating antihistamine. This case illustrates the importance of pilot outreach and education regarding appropriate medication choices and awareness of side effects and needed wait times when using over the counter medications.

#### Learning Objectives

1. Identify the flight safety risks posed by the use of sedating antihistamines.
2. Recognize the need for educating pilots on the use of potentially impairing non-prescription medications when flying and your role as a health care provider in educating them.

Monday, 05/22/2023  
Napoleon Ballroom C1-C2

2:00 PM

### [S-14]: SLIDES: JUST LIKE THE AIRCRAFT!

Chair: Timothy Welsh  
Co-Chair: Megan Gallo

#### [74] EVALUATION OF THE PHYSIOLOGICAL IMPACT OF FOUR DIFFERENT BASELINE ACCELERATIONS ON A HUMAN CENTRIFUGE

Bonnie Posselt<sup>1</sup>, Joseph Britton<sup>1</sup>, Adam Peters<sup>2</sup>, Charlotte Thornton-White<sup>2</sup>, Stephen Harridge<sup>2</sup>, Nicholas Green<sup>1</sup>, Ross Pollock<sup>2</sup>

<sup>1</sup>RAF Centre of Aviation Medicine, Henlow, United Kingdom; <sup>2</sup>King's College London, London, United Kingdom

(Original Research)

**INTRODUCTION:** Human centrifuges utilize baseline accelerations between high-G exposures to optimise mechanical performance and minimise motion sickness, with +1.4 and +1.6 Gz most frequently used. The physiological changes associated with these low levels of +Gz have not been characterized in detail, limiting analysis of their impact on trials and training. **METHODS:** 10 subjects (Age:  $34 \pm 10.2$  yr; mean  $\pm$  SD) participated in a human centrifuge trial (centrifuge arm length = 7.5m, seatback angle = 22°). 2-minute exposures to +1.2, +1.4, +1.6 and +1.8 Gz were performed in a random order, with 5 minutes at +1 Gz between runs. Blood pressure (Systolic; SBP and diastolic; DBP and mean arterial pressure; MAP) and cardiovascular variables (Cardiac output; CO, stroke volume; SV, total peripheral resistance; TPR) were assessed via the volume-clamp method. Heart rate (HR) was assessed from 3-lead ECG. Blood volume changes in the abdomen, thigh, knee and calf were measured via impedance plethysmography. Subjective motion sickness ratings were performed using the 11-point MIsery Scale (MISC) after each run. **RESULTS:** Between +1 Gz and the four baselines assessed there was an effect of acceleration on CO, SV, HR and TPR, MAP and DBP at both heart and head-level and SBP at head-level only. Compared to +1 Gz, at +1.8 Gz heart-level DBP was increased by  $13.9 \pm 8.3$  %, TPR by  $30.8 \pm 18.6$  % an HR by  $11.9 \pm 7.2$  %, whilst CO was reduced by  $17 \pm 8.5$  % and SV by  $27 \pm 4.3$  %. Head-level MAP fell by  $41.3$  % at +1.8 Gz. There was an effect of acceleration on blood volume in all segments with an increase of approximately 495 ml in total at +1.8 Gz. Changes in blood volume were greatest in the abdomen and thigh, with limited changes in the knee and calf segments. There was no difference in MISC score between baselines. **DISCUSSION:** The direction and magnitude of change in cardiovascular variables was of similar magnitude at +1.6 and +1.8 Gz as those previously reported to occur during postural change from supine (0 Gz) to standing (+1 Gz). Selecting baselines of +1.2 or +1.4 Gz reduces physiological priming. Decisions on which baseline to use will largely depend on the context, including importance of proximity to +1 Gz values and the requirement to minimise motion sickness.

##### Learning Objectives

1. The audience will learn about the physiological effects of different amounts of baseline +Gz.
2. The audience will learn about the factors that affect selection of an appropriate baseline +Gz level.

#### [75] THE ROLE OF JUGULAR VEIN RESISTANCE IN G-INDUCED LOSS OF CONSCIOUSNESS

William Fraser

Silatuk Research, Toronto, ONT, Canada

(Original Research)

**INTRODUCTION:** A common explanation for G-Induced-Loss-of-Consciousness (GLOC) is the failure of the heart to overcome the elevated Gz force acting on the heart-to-head column of blood and to maintain sufficient perfusion of the brain. It has been a puzzle as to why the so-called siphon effect cannot maintain blood flow to the brain under Gz, as siphons function up to a height of 13m. Mechanical and computer simulations have indicated that the decrease in non-pulsatile cerebral blood flow during Gz exposure is due to the negative pressure-induced partial collapse and subsequent increase in the hydraulic resistance of the jugular vein. It is not clear whether this entirely explains GLOC given the pulsatile nature of flow in the cardiovascular system where blood in the left ventricle has to be accelerated against the gravitational force

during systole. **METHOD:** A simple mechanical simulator of the pulsatile circulation consisting of an atrium, a ventricle, polyvinylchloride tubing, and a heart-to-brain distance of 1m was used to determine the impact of Gz on cerebral blood flow. The force applied to the ventricle and the blood flow was measured in horizontal and vertical orientations. In a second experiment, the return line to the atrium was replaced with compliant tubing simulating a thin-walled jugular vein. The two experimental conditions were also simulated with a mathematical model. **RESULTS:** With a non-compliant jugular vein, the force applied to the left ventricle to generate a given flow rate was identical for the horizontal and vertical positions. The compliant jugular vein analog partially collapsed in the vertical orientation and the flow rate was reduced in spite of an identical force acting on the ventricle. Simulations confirmed that the decrease in pulsatile blood flow is a function of the length and compliance of the jugular vein. **DISCUSSION:** Even during pulsatile flow the decrease in blood flow in the brain under Gz exposure is not due to a failure of the heart to pump blood uphill, but rather the indirect effect of the Gz-induced negative pressure increasing vascular resistance in compliant veins. Gz protection equipment acts to maintain cardiac output, maintain normal perfusion pressure, and minimize an increased resistance of the cerebral drainage vasculature. The non-linear, time-dependent biomechanical properties of the jugular and other neck veins may be critical in determining the risk of GLOC during complex Gz transitions.

##### Learning Objectives

1. The participant will be able to understand the potential of mechanical cardiovascular simulators in investigating the physiological responses to sustained acceleration.
2. The participant will be able to understand the role of the compliance of the jugular and other neck veins in the physiological mechanisms involved in G-induced Loss of Consciousness (GLOC).

#### [76] VALIDATION OF A NOVEL VISUAL ENDPOINT FOR ACCELERATION RESEARCH: EVIDENCE TO SUPPORT A REVISED MODEL OF VISUAL CHANGES UNDER +GZ

Joseph Britton<sup>1</sup>, Desmond Connolly<sup>2</sup>, Danielle Hawarden<sup>1</sup>, Alec Stevenson<sup>2</sup>, Stephen Harridge<sup>3</sup>, Nicholas Green<sup>1</sup>

<sup>1</sup>RAF Centre of Aviation Medicine, Henlow, United Kingdom; <sup>2</sup>QinetiQ PLC, Farnborough, United Kingdom; <sup>3</sup>King's College London, London, United Kingdom

(Original Research)

**BACKGROUND:** G-tolerance in human centrifuge research is often assessed using the Peripheral Light Loss (PLL) technique. This has several limitations including reduced accuracy at high levels of +Gz acceleration, subject training requirements and variations between research centres due to lighting conditions. A novel visual endpoint (BEAR; Britton Endpoint for Acceleration Research) was developed based on predicted changes in contrast sensitivity under +Gz and validated across a range of centrifuge exposures. **METHODS:** 12 subjects ( $34.1 \pm 8.4$  yr; mean  $\pm$  SD) with confirmed normal visual acuity and colour sensitivity undertook centrifuge assessment to determine the repeatability and reliability of the BEAR in comparison with PLL measured at 60° arc. Gradual onset exposures (GOR; 0.1 G/sec) were performed twice on separate days and consisted of six repeats with (GOR-On) and without (GOR-Off) Full Coverage Anti-G Trousers activated. Rapid onset exposures (ROR), repeated four times, consisted of a single determination of PLL and BEAR. The usability of each endpoint was subjectively scored following each session. **RESULTS:** When used to measure G-thresholds, the BEAR had excellent test-retest repeatability (ICC; GOR-Off/On = 0.99, ROR = 0.92) and low within-subject variability. Between-subject variance was equal to PLL in all conditions. Between-session variance in GOR conditions was statistically but not biologically significant for both endpoints ( $\Delta = 0.08$  Gz). There was a strong correlation between BEAR and PLL in GOR-Off ( $r = .93$ ), GOR-On ( $r = .95$ ) and ROR ( $r = .86$ ). Mean threshold values were significantly lower when using BEAR than when using PLL, by 0.3 Gz on average in GOR-Off and by 0.5 Gz in both GOR-On and ROR. Both tests were able to detect changes in G-protection status. Subjective

endpoint ratings were equal in all conditions. **DISCUSSION:** This study confirmed that the ability to detect a contrast stimulus is affected by +Gz acceleration and that this can be used to generate a visual endpoint. The BEAR demonstrated content and construct validity in assessment alongside the established PLL technique. This study also identified that central contrast sensitivity is affected at a lower +Gz than PLL. This provides evidence against the theory of +Gz related visual changes as a peripheral to central retinal failure and supports a more complex progressive shift in visual perception thresholds across the entire retina.

#### Learning Objectives

1. The audience will learn about the design, use and validation of a novel visual endpoint for use in G-tolerance determinations on a human centrifuge.
2. The audience will gain understanding of how the validation of this novel visual endpoint provides new evidence to the changes in vision under +Gz acceleration.

### [77] EFFECT OF AGE AND FLYING EXPERIENCE ON HEART RATE RESPONSE OF FIGHTER AIRCREW DURING HIGH-G EXPOSURE IN THE HIGH PERFORMANCE HUMAN CENTRIFUGE

Ajay Kumar

Indian Air Force, Jodhpur, India

#### (Original Research)

**INTRODUCTION:** Institute of Aerospace Medicine Indian Air Force regularly conducts high G training in the human rated high performance human centrifuge (HPHC) for fighter aircrew. It was hypothesized that the cardiovascular response of young and inexperienced pilots who undergo training in the HPHC may be different from the elder and experienced pilots as age and flying experience may have some effect on the CVS response to high-G exposure. **MATERIAL AND METHODS:** A retrospective analysis of the heart rate data from the data bank of the Department of Acceleration Physiology and Spatial Orientation was done to understand differences in heart rate response between young and older fighter aircrew. **RESULTS:** A total of 624 successful HPHC runs were evaluated for the baseline heart rate (before high-G exposure), peak heart rate (during the exposure) and heart rate after the exposure of the run. The mean age, height and weight of the subjects were  $27.62 \pm 5.5$  yr,  $175.31 \pm 4.8$  cm and  $72.81 \pm 8.4$  kg respectively. Student's t-test revealed a significant difference in the basal heart rate and peak heart rate during the high-G exposure between young, inexperienced and older experienced pilots. **DISCUSSION:** Higher basal heart rate and peak heart rate during high-G exposure among younger pilots could be explained by anxiety due to inexperience and a tendency to pull harder compared to other pilots who with experience tend to be more adjusted and pull slower to meet the desired G-level during the high G training. **CONCLUSION:** The cardiovascular response during exposure to high G environment significantly differs between young, inexperienced pilots and senior pilots.

#### Learning Objectives

1. Effect of heart rate on exposure to various G-profiles during high-G training.
2. Effect of age of the pilot on heart rate response during high-G training.
3. Effect of experience of the pilot on heart rate response during high-G training.

### [78] WORK OF BREATH EFFECTS ON SUSTAINED ATTENTION & EXECUTIVE CONTROL PERFORMANCE

Rachel Goehring<sup>1</sup>, Tim Halverson<sup>2</sup>, Bruce Johnson<sup>3</sup>, Robert Wentz<sup>3</sup>, Christopher Myers<sup>4</sup>, Nicholas Napoli<sup>5</sup>

<sup>1</sup>U.S. Air Force Academy, Colorado Springs, CO, United States; <sup>2</sup>Aptima, Inc., Eugene, OR, United States; <sup>3</sup>Mayo Clinic, Rochester, MN, United States; <sup>4</sup>U.S. Air Force Research Lab, Dayton, OH, United States; <sup>5</sup>University of Florida, Gainesville, FL, United States

#### (Original Research)

**INTRODUCTION:** A pilot's work of breathing (WoB), the energy expended by the respiratory muscles to produce adequate ventilation, can negatively impact the aviator's cognitive performance. We evaluate how repetitions of applied breathing loads affect cognitive response times (RTs), and if there is any breathing adaptation when loads are reintroduced. **METHODS:** We analyzed data from a version of the conjunctive continuous performance task (CCPT) which is a sustained attention, executive control task. Participants were presented with a visual stimulus to respond to based on shape and color while different breathing loads at 0, 20, 40, and 60% of their maximum inspiratory pressure (MIP) were applied. There were 12 subjects that performed 48 combinations of varying MIPs over 2 visits examining inspiration and expiration respectively. Each consisted of 40 trials over approximately 4 minutes. **RESULTS:** Analyses focused on the effects of breathing load, time on task, and features shared between the 'right' and 'wrong' stimuli. Linear mixed-effect models (lme4) and post hoc comparisons (emmeans) were performed in the R environment. There was an interaction between breathing load and time on task ( $p < 0.001$ ), where RTs with breathing loads were slower than without breathing loads. Interestingly, there was a greater time-on-task effect for low and no breathing loads. RTs started slower with greater breathing load but were fairly equivalent across all four conditions by the 40th trial. The effects of time-on-task were greater for the low and no breathing loads relative to moderate and heavy. All contrasts for heavy or moderate compared to light or no load were significant ( $P < 0.001$ ), but there was no evidence for differences between heavy and moderate time-on-task effects,  $P = 0.965$  or between light and none,  $P = 0.270$ . Errors of omission varied with breathing load ( $P < 0.001$ ) in a manner consistent with RTs. **DISCUSSION:** The heavier two loads had slower RTs at the start, but the subjects RT time later adjusted to similar RTs of lighter two loads' RTs. There is evidence to support that through breathing adaptations, subjects can regain their cognitive abilities after learning how to adapt resistive respiratory loads.

#### Learning Objectives

1. Insights on adjusting your pattern of breathing during varying respiratory loads will be discussed in order to avoid increases in cognitive RT.
2. Trends of the RTs due to the stimuli's shared features are explored in relation to the breathing loads that the pilots are experiencing.

### [79] AN ADAPTED MUSCULOSKELETAL MODEL TO PREDICT FAST JET PILOT NECK MUSCLE ACTIVATIONS AT +GZ

Dominic Pulford, Olivia Winther, Alec Stevenson,

Rory Macintyre Merz

QinetiQ PLC, Farnborough, United Kingdom

#### (Original Research)

**INTRODUCTION:** Computational models can be used to predict neck muscle activations to inform musculoskeletal injury risk in fast jet pilots. The aim of this study was to adapt an existing musculoskeletal model, informed by in-flight head position and centrifuge electromyography data, and assess its predictive capability. **METHODS:** Eight flight sorties in the Typhoon aircraft were performed with pilots wearing a helmet-mounted display system which included head-tracking. +Gz acceleration, head angles and in-cockpit video footage were recorded. Head postures were characterized and four common pilot head movements identified. Four non-aircrew volunteers replicated the pilot head movements in a human carrying centrifuge at +1, +3 and +5 Gz wearing a head tracking device and surface electromyography (sEMG) electrodes on four neck muscles (bilaterally). Normalized sEMG data (% of maximum voluntary contraction; MVC) was used to inform modifications to an open source musculoskeletal model of the neck (OpenSim). **RESULTS:** On average, the pilots head was out of neutral (OoN) 60.1% of the time (62.9% when  $>2$  Gz) while only a fraction of the flight sortie (14.5%) was spent above +2 Gz. During level flight, the majority of head movement was in flexion (49%). Whilst at +Gz, the majority of movements were in rotation (51%), then flexion (21%), followed by extension

with rotation (20%), and extension only (7%). The contribution of flexion to the OoN postures decreased with +Gz, being virtually absent at accelerations above +4 Gz. Overall, the error of the model predictions (root mean square error; RMSE) was reduced by 0.5% at +1 Gz, 2.7% at +3 Gz and 5.2% at +5 Gz. **CONCLUSION:** Exposure to +Gz acceleration accounts for a small proportion of sortie duration. Pilot's heads were positioned OoN for the majority of the sortie duration with adopted head postures influenced by +Gz (increase in extension and rotation movements with >Gz at the expense of flexion). sEMG showed the check-six movement elicited the largest mean neck muscle activation ( $34.5 \pm 18.4\% +5$  Gz), followed by rotation ( $33.2 \pm 24.7\% +5$  Gz), flexion ( $27.3 \pm 14.9\% +5$  Gz) and extension ( $12.4 \pm 0.31\% +5$  Gz). While the musculoskeletal model predictions were enhanced, there is scope for further improvement.

#### Learning Objectives

1. The audience will learn about typical fast jet (Typhoon) pilot movements/postures and exposure to +Gz acceleration.
2. The audience will learn about the typical neck muscle activations associated with flexion, extension, rotation and 'check 6' movements at various +Gz levels.
3. The audience will learn about the modifications made to a musculoskeletal model to improve its capabilities to predict neck loading in the fast jet environment.

**Monday, 05/22/2023**  
**Napoleon Ballroom D1-D2**

**2:00 PM**

### [S-15]: PANEL: OPERATIONAL VISION I: COLOR AND VISION STANDARDS

**Chair: Steven Hadley**

**Co-Chair: Marc Winterbottom**

**PANEL OVERVIEW:** Multiple organizations are pursuing research through interservice and international collaborative efforts to examine the relationship between vision and operationally relevant performance. The objectives of this research include defining the visual performance capability that will contribute to success of the mission, developing operational based vision standards and waiver criteria, and identifying design factors that impact performance with the use of vision enhancement and vision protection devices. Operational Vision research across these organizations is presented in two panels: Operational Vision I: Color and Vision Standards and Operational Vision II: Visual Performance and Protection. The first panel focuses on color and color vision standards. The first presentation in Operational Vision I, from Defence Research and Development Canada (DRDC), provides an evaluation of color displays in Royal Canadian Air Force aircraft and importance of color vision standards. The second presentation, from the 711th Human Performance Wing (711 HPW) Operational Based Vision Assessment (OBVA) Lab, describes research examining the impact of filtered gamer glasses on simulated remotely piloted aircraft (RPA) operator performance. The third presentation, also from the 711 HPW OBVA Lab, describes research examining the impact of EnChroma glasses on simulated remotely piloted aircraft (RPA) operator performance. The fourth presentation, from the University of the Incarnate Word, describes additional research examining the effect of EnChroma color vision correcting lenses and new metrics for quantifying color performance. A fifth presentation, by the University of Waterloo and DRDC, describes research comparing screening outcomes for several color vision tests, including the cone contrast test at a pass/fail criterion of 55.

### [80] COLOR VISION DEMANDS FOR AIRCREW IN THE CANADIAN FORCES

Mackenzie G Glaholt<sup>1</sup>, Jeffery K Hovis<sup>2</sup>

<sup>1</sup>DRDC, Toronto, ONT, Canada; <sup>2</sup>University of Waterloo, Waterloo, ONT, Canada

(Original Research)

**INTRODUCTION:** Color is used extensively in modern military aircraft to convey information to aircrew. The current Royal Canadian Air Force (RCAF) vision standard for pilots excludes individuals with severe color vision deficiency. This standard was derived 30 years ago, and since then, many new aviation displays incorporating color have been introduced into military cockpits. These displays potentially impose new demands for color vision upon RCAF aircrew that must be examined. **METHODS:** Eighteen aircraft from the RCAF fleet were investigated to identify the color-related tasks. We had discussions with the aircrew (at least two per aircraft) about the use of color in the aircraft and measured colors used in the aircraft displays with a Pritchard PR-670 spectrophotometer. The color data were analyzed to determine whether an individual with a severe color vision defect would likely make a mistake in identifying the colors used in a given display. **RESULTS:** Of particular interest were color-related tasks where color was the sole means of conveying information to the aircrew or redundant non-color cues were subtle. We found twelve of these tasks in the cockpit/cabin (e.g., identification of colors used in aircraft systems displays, navigation indicators, weather radar, ground avoidance systems, ground radar, and other digital displays in the cockpit) and nine tasks exterior to the aircraft (e.g., identifying colors of ground vehicles, signal lights, smoke, and flares). Analyses of measured colorimetric values showed that an individual with a severe color vision defect would have difficulty performing these tasks. **DISCUSSION:** The results confirm that color vision demands are prevalent in modern military aviation and that the RCAF should continue to screen for severe color vision deficiency. In addition, the data from this study can be used to develop task simulations based on colors common to many cockpit displays and common exterior signal lights. These task simulations could, in turn, be used to determine the appropriate cut-off score for newer quantitative color vision tests to ensure that candidates can successfully perform the color-related tasks encountered by RCAF pilots and other aircrew.

#### Learning Objectives

1. Understand which colors individuals with color vision deficiencies confuse.
2. Understand possible color vision demands in the military aircraft.

### [81] EFFECT OF GUNNAR COMPUTER GLASSES ON SIMULATED REMOTELY PILOTED AIRCRAFT COLOR-CODED DISPLAY TASKS

Marc Winterbottom<sup>1</sup>, James Gaska<sup>2</sup>, Steven Hadley<sup>1</sup>

<sup>1</sup>Airman Systems Directorate, Operational Based Vision Assessment Laboratory, Wright-Patterson AFB, OH, United States; <sup>2</sup>Retired, Airman Systems Directorate, Operational Based Vision Assessment Laboratory, Wright-Patterson AFB, OH, United States

(Original Research)

**INTRODUCTION:** Remotely piloted aircraft (RPA) operators spend many hours viewing digital displays, thus have increased risk of digital eye strain (DES). Techniques to ameliorate DES include improving image quality, reducing glare, and frequent breaks. Eyewear can potentially reduce DES, and some RPA operators have reported using Gunnar glasses. We examined the effect of Gunnar Amber glasses on color test scores and performance on simulated RPA color display tasks. **METHODS:** Color deficiency and effect of eyewear on color discrimination was assessed using a cone contrast test (CCT) for 8 color normal and 10 red-green deficient participants. Sensor and system status ("STORM") displays simulated those in the MQ-9 ground control station. The sensor task required observers to locate red/green or blue/yellow vehicles; the STORM task required observers to respond to red, green, or yellow color-coded warnings. For one experiment, stimulus contrast was fixed, and speed/accuracy (throughput) was measured. In a second experiment, performed on the sensor display, target contrast was varied to estimate contrast sensitivity required. Throughput and contrast thresholds were compared with and without (Direct View) eyewear. **RESULTS:** Eyewear had little effect on CCT scores. For red/green cones, CCT thresholds for Gunnar – Direct View

= 0.04, SEM = 0.02. For blue cones, CCT thresholds for Gunnar – Direct View = - 0.068, SEM = 0.028. For sensor display contrast sensitivity, eyewear had little effect. The difference in throughput for red/green sensor targets was Gunnar – Direct View = 0.073, SEM = 0.04. Difference in throughput for blue/yellow sensor targets was Gunnar – Direct View = 0.057, SEM = 0.045. For STORM warning discrimination, difference in throughput was Gunnar – Direct View = 0.13, SEM = 0.039. **DISCUSSION:** Gunnar eyewear did not have a negative impact on the ability of observers to identify color coded information, including blue/yellow imagery. Little effect was found for color normal or color deficient individuals. Given the potentially beneficial effects of a small dioptric add, blue light filtering, and potentially reduced eye dryness, the use of eyewear such as the Gunnar glasses, should be given more consideration for RPA operators using digital displays for long periods of time to reduce DES.

#### Learning Objectives

1. The audience will learn about the effect of color deficiency on color coded display tasks, similar to those used in RPA ground control stations.
2. The audience will learn what effect color filter lenses, such as blue blocking lenses used in some computer/gamer glasses, have on the use of color coded displays.

### [82] EFFECT OF ENCHROMA GLASSES ON COLOR VISION TESTING AND SIMULATED REMOTELY PILOTED AIRCRAFT COLOR-CODED DISPLAY TASKS

Steven Hadley, Marc Winterbottom, James Gaska  
711th Human Performance Wing, Wright-Patterson AFB, OH, United States

#### (Original Research)

**INTRODUCTION:** Historically, color vision deficiency (CVD) results in the highest USAF pilot applicant medical disqualification. EnChroma glasses are marketed to improve color perception for CVD. If effective, this technology could allow CVD applicants to qualify. We examined the effect of EnChroma glasses on color test scores and performance on simulated RPA color display tasks. **METHODS:** Fifteen participants (8 color normal, 7 CVD) completed this IRB approved study. CVD and effect of EnChroma glasses was assessed with the new CCT-HD. Verified simulation of the MQ-9 electro-optical sensor display and "STORM" was utilized. The sensor display task required the observer locate a red/green or blue/yellow car and the STORM task required observers to respond to a red, green, or yellow color-coded warning. The stimulus contrast was fixed then varied with speed/accuracy and contrast sensitivity thresholds required to identify the color target measured and compared for participants with and without (Direct View) eyewear.

**RESULTS:** The EnChroma glasses had very little effect on CCT scores, for color normal or color deficient participants. For red/green cones, log contrast CCT thresholds for EnChroma – Direct View = 0.067, SEM = 0.021. For blue cones, log contrast CCT thresholds for EnChroma – Direct View = - 0.052, SEM = 0.032. Similarly, for simulated sensor display contrast sensitivity, EnChroma glasses had very little effect. The difference in throughput (speed/accuracy) for red/green sensor targets was EnChroma – Direct View = 0.12, SEM = 0.038. The difference in throughput (speed/accuracy) for blue/yellow sensor targets was EnChroma – Direct View = 0.10, SEM = 0.038. For the STORM warning discrimination, difference in throughput was EnChroma – Direct View = 0.17, SEM = 0.042. **DISCUSSION:** EnChroma glasses had no effect on either CCT-HD scores or contrast sensitivity to discriminate red/green or blue/yellow vehicles in a simulated RPA sensor display task. EnChroma glasses resulted in a small improvement in throughput for the simulated vehicle identification task and STORM color warning task. However, this improvement was very small and unlikely to result in an operationally relevant improvement in performance. This is consistent with previous research which similarly did not result in significantly improved color discrimination for color deficient individuals.

#### Learning Objectives

1. The audience will learn EnChroma glasses will not allow color deficient applicants that previously failed USAF color vision testing to pass with the glasses.
2. The audience will learn EnChroma glasses are not expected to improve color vision deficiency operational performance in color demanding tasks in the USAF MQ-9.

### [83] NEW METRICS FOR QUANTIFYING COLOR: OPERATIONAL AND CLINICAL APPLICATIONS

Erica Poole, Frances Silva, Jeff Rabin  
University of the Incarnate Word, San Antonio, TX, United States

#### (Original Research)

**INTRODUCTION:** Color vision deficiency (CVD) can reduce performance and delay response time in cue limited settings. A gap exists between the relation between CVD type/severity & real-world performance. Our purpose is to describe new metrics of color vision better matched to operational performance, occupational selection, and eye disease detection. **METHODS:** Subjects provided written informed consent in accord with IRB approved protocols and confirmed to be CVDs or color vision normal (CVNs) based on Ishihara and anomaloscope testing. Throughput (TP), response amplitude/response time, was evaluated for cone contrast sensitivity (Cone CS) and Cone VEPs (cVEPs). Cone CS TP was measured in 25 CVDs & 25 CVNs. Efficacy of Cone CS and cVEP TP for showing improvements in CVDs wearing EnChroma color correcting lenses (CCLs) was assessed in 13 CVDs. Lastly, we developed and validated the Cone Contrast Naming Test (CCNT) which combines Cone CS and color naming accuracy (CN) in 20 CVDs & 26 CVNs. ANOVA, t-tests, Wilcoxon, Bland-Altman, and regression analyses were used. **RESULTS:** In 25 CVNs mean/SD Cone CS TP: R cone  $36.8 \pm 7.4$ , G  $36.7 \pm 8.7$ , B  $54.5 \pm 10.0$ ; no difference between R & G cone TP ( $P=.96$ ) but higher B cone TP due to B CS ceiling effect. In 25 CVDs: Protan Red Cone CS TP  $2.7 \pm 1.4$  < CVNs ( $36.8$ ;  $4.6$  SDs below normal) and Green Cone CS TP in same subjects ( $30.5$ ,  $P<0.001$ ); Deutan Green Cone TP  $10 \pm 5.6$ , < CVNs ( $36.7$ ;  $3.1$  SDs below normal) and Red Cone TP in same subjects ( $30.5$ ,  $P<0.001$ ). Examples of how Cone CS TP enhances occupational selection & disease detection are included. Our pilot study of CCLs showed immediate & long-term improvements in CVDs with greatest enhancement of cVEP TP ( $P<.0001$ ) and Cone CS TP for the CVD cone type ( $P<0.001$ ). 100% of CVDs showed increased TP ( $P<0.001$ ). No subjects showed differences in TP with or without CCLs for the normal cone type ( $P>0.61$ ). In CVDs CCNT Cone CS scores correlated with Innova CCT scores ( $r^2 = 0.8$ ,  $P<.001$ ) as did CVN Cone CS ( $r^2 = 0.3$ ,  $P<0.001$ ) & with anomaloscope matching range ( $P<0.03$ ). CCNT Cone CS and CCNT CN sensitivity for detection of CVD were 100% and specificity of CVD normal cone types and CVNs were 100%. CCNT composite scores (mean of CS & CN) yielded greater diversity of scores (70%) in CVDs vs. CS alone. **CONCLUSIONS:** Both TP & the CCNT are important additions to color testing using dual metrics to potentially improve occupational selection and earlier detection of acquired CVD in disease.

#### Learning Objectives

1. The audience will learn about throughput as a metric which may show utility as a more sensitive tool for quantifying color deficiency in operational settings.
2. The audience will learn about a new cone contrast test which quantifies cone contrast sensitivity as well as the accuracy of color naming.

### [84] A COMPARISON OF COMPUTER-BASED COLOR VISION TESTS USING THE "55" SCORE

Jeffery K Hovis<sup>1</sup>, Ali H Almustanyir<sup>1</sup>, Mackenzie G Glaholt<sup>2</sup>  
<sup>1</sup>University of Waterloo, Waterloo, ONT, Canada; <sup>2</sup>University of Waterloo, Waterloo, ONT, Canada; <sup>3</sup>DRDC, Toronto, ONT, Canada

#### (Original Research)

**INTRODUCTION:** The common color vision standard for the United States Military Aviators is that the candidate must obtain a score of at

least 55 on the Rabin Cone Contrast Color Vision Test (RCCT). However, other computer-based tests can also estimate the severity of the defect by measuring chromatic thresholds on a gray background, but there is little information on how they compare with the RCCT using the <55 failure criterion. **METHODS:** We compared the Operational Based Color Vision Test (OBCVT), Cambridge TriVector (CTV), and Color Assessment and Diagnosis (CAD) with RCCT. Sixty individuals with normal color vision and 68 subjects with red-green color vision deficiencies participated. The Rayleigh color match was used to classify the subjects' color vision. The RCCT and CTV were performed monocularly, and the CAD was performed binocularly. The OBCVT was performed monocularly and binocularly. For the monocular tests, the data from each eye were averaged for this comparison. Receiver Operator Curves (ROC) analysis was used to establish cut-off scores for the CTV and CAD tests. Correlations and agreements with RCCT were determined. **RESULTS:** All color-normals passed the RCCT using the 55 cut-off score. They also passed the other tests using the corresponding pass/fail values. For the color-defectives, the correlations between the RCCT and the other tests ranged from  $r=0.5$  for the CTV to  $r=0.8$  for OBCVT performed binocularly. The AC1 pass/fail agreement values of the RCCT with the other tests varied from  $AC1=0.56$  for the CAD to  $AC1=0.79$  for the OBCVT viewed binocularly. The primary reason for the less-than-ideal agreement is that the other tests had a low ( $\sim 0.50$ ) specificity relative to the RCCT. The other finding related to the relatively low specificity was that 7.5% of the dichromats passed the RCCT but not the other tests. **CONCLUSIONS:** The agreement of other computer-based chromatic threshold tests with the RCCT when using a criterion that allows "mild" color-defectives to pass is moderate-to-good. The agreement is highest with the OBCVT, which used similar stimuli. The primary source of discrepancies is individuals who pass the RCCT but fail the other tests.

#### Learning Objectives

1. Understand the design of several color vision tests that measure chromatic thresholds.
2. The audience will learn how several computer-based color vision tests compare when individuals with a mild color vision defect are allowed to pass.

Monday, 05/22/2023

2:00 PM

Napoleon C3

### [S-16]: PANEL: DISORIENTATION AND OPERATIONAL PERFORMANCE IN LAYPERSON CENTRIFUGE-SIMULATED SPACEFLIGHT

Chair: Rebecca Blue

Co-Chair: Karen Ong

**PANEL OVERVIEW:** Individuals considering participation in commercial suborbital spaceflight represent a varied population inclusive of a wide range of medical conditions, ages, and degrees of preparation for flight. The majority of the knowledge of the human body and performance in high-performance environments is based upon studies of healthy individuals well-trained for such activities. However, prospective commercial spaceflight participants will self-select based upon financial means and opportunity, factors which are often inversely related to youth and physical fitness. With very little data regarding the effects of spaceflight on individuals with known medical conditions, the screening and training of commercial passengers is currently an area of much discussion and debate. To address these issues, a study was conducted under funding from the FAA Center of Excellence for Commercial Space Transportation in which layperson volunteers were exposed to high-fidelity centrifuge-simulated suborbital spaceflight. This panel will review key findings from this study, addressing tolerance, performance, and accommodation of needs specific to the layperson and spaceflight participant populations.

### [85] LAYPERSON PHYSIOLOGICAL TOLERANCE IN CENTRIFUGE-SIMULATED SUBORBITAL AND ORBITAL SPACEFLIGHT

Kristi Ray<sup>1</sup>, Karen Ong<sup>1</sup>, Anil Menon<sup>2</sup>, Jaime Mateus<sup>3</sup>, Serena Auñon-Chancellor<sup>1</sup>, Ronak Shah<sup>1</sup>, William Powers<sup>1</sup>, Rebecca Blue<sup>1</sup>  
<sup>1</sup>UTMB, Galveston, TX, United States; <sup>2</sup>NASA JSC, Houston, TX, United States; <sup>3</sup>SpaceX, LLC, Hawthorne, CA, United States

#### (Original Research)

**INTRODUCTION:** Prior study has indicated that individuals of varied age and limited-to-no experience in an operational environment, including those with well-controlled medical conditions, can tolerate spaceflight and analog conditions. Here we sought to expand upon the understanding of how individuals of varied age and medical history respond to hypergravity conditions expected in spaceflight. We sought to expose laypersons without introductory step-wise hypergravity exposure, to centrifuge-simulated, high-fidelity spaceflight profiles representative of both capsular and winged vehicle designs. **SUBJECTS:** Volunteer subjects participated in up to five centrifuge runs in an 8-hour period, simulating both winged and capsule spaceflight. Maximum exposures included  $+4.0G_z$ ,  $+4.5G_x$ ,  $6.1G$  resultant, and maximum onset rate  $<0.5G_z/sec$  and  $+1G_x/sec$ . Profiles included two simulated "flights" in a winged spacecraft, with sequential and combined  $+G_x/+G_z$  exposures, and two simulated capsule profiles representing nominal  $+G_x$  launch and reentry forces. The final profile simulated a capsule launch with abort and activation of the launch escape system; with a more dynamic cycling of  $+G_x$  exposures and oscillatory multi-axis exposures simulating parachute swing and capsule motion after water landing. **RESULTS:** Forty-six subjects participated in the study including 4 participants with diabetes mellitus, 9 participants with significant cardiac history, and other variable medical histories. Subjects tolerated centrifuge profiles reasonably well, though notably there was a significant increase in the frequency of nausea symptoms associated with capsule-type profiles that exceeded rates of motion sickness reported in prior studies of this kind. Similarly, there was a significant increase in the frequency of subjects voluntarily terminating participation prior to completion of all profiles. Subjects most frequently cited nausea or motion sickness as the reason for non-completion, and often attributed symptoms to discordant visual cues during capsule runs as contributing to discomfort or prompting withdrawal. **DISCUSSION:** This study further adds to the available literature basis for understanding of layperson tolerance in commercial spaceflight analog conditions. The inclusion of capsular profiles broadens the applicability of findings to multiple vehicle designs and provides additional understanding of layperson responses to variable hypergravity environments.

#### Learning Objectives

1. The audience will learn about layperson tolerance to commercial spaceflight exposures.
2. The audience will learn about the applicability of research findings to multiple vehicle designs.

### [86] LAYPERSON TASK PERFORMANCE IN SPACEFLIGHT-ANALOG CONDITIONS

Rebecca Blue<sup>1</sup>, Karen Ong<sup>1</sup>, Kristi Ray<sup>1</sup>, Anil Menon<sup>2</sup>, Jaime Mateus<sup>3</sup>, Serena Auñon-Chancellor<sup>1</sup>, Ronak Shah<sup>1</sup>, William Powers<sup>1</sup>  
<sup>1</sup>UTMB, Galveston, TX, United States; <sup>2</sup>NASA JSC, Houston, TX, United States; <sup>3</sup>SpaceX, LLC, Hawthorne, CA, United States

#### (Original Research)

**INTRODUCTION:** Inclusion of laypersons in the spaceflight environment has raised questions regarding the performance capabilities of such individuals in critical situations. Prior study has lacked tangible evidence regarding operational performance of laypersons, particularly during exposure to space-analog environmental stressors such as hypergravity.

We sought to expand the understanding of minimally trained layperson performance in simulated operations during and immediately following hypergravity exposure. We examined subject task performance on a touchscreen tablet before, during, and after centrifugation. **METHODS:** Pattern-replication tasks were administered to volunteer subjects participating in a larger centrifuge study. Subjects participated in up to five centrifuge runs in one day, with profiles simulating commercial spaceflight. Maximum exposures included  $+4.0G_z$ ,  $+4.5G_x$ ,  $6.1G$  resultant, and maximum onset rate  $<0.5G_z/\text{sec}$  and  $+1G_x/\text{sec}$ . Tablet tasks included pressing tablet buttons to recreate a predetermined light pattern as indicated by cue-cards available for reference in the gondola. Subjects received familiarization training and were instructed to treat tablet tasks as simulated emergency procedures. They were informed that they would be scored based on time and accuracy, with the goal of perfect accuracy at the fastest pace possible. **RESULTS:** Subjects reported feeling comfortable with the simulated tasks, with adequate time for practice. Most subjects did not continue to practice after the first exam, though practice effort was not associated with exam performance. Average time to complete the tests and to deploy the lightboard under hypergravity conditions were linearly associated with age. There was no association between any time metric or accuracy and sex. Errors were common, including wrong entries, wrong cue-card references, and wrong identifier entries. **DISCUSSION:** The frequency of lightboard error in this study highlights the potential for mistakes in operational activities when performed by laypersons. While entry mistakes represent low-risk events in an analog environment, similar mistakes (referencing wrong cue-cards, entering wrong actions) in an operational environment could be catastrophic. These findings highlight the need for further study to determine the best approach to training, procedural design, and simplicity of actions to best accommodate critical actions of laypersons in the case of operational emergency.

#### Learning Objectives

1. The audience will learn about layperson operational performance in simulated spaceflight environments.
2. We will discuss frequency of error and types of errors in simulated emergency tasks performed by layperson in simulated spaceflight environments.

#### [87] EVALUATION AND ACCOMMODATION OF MOBILITY LIMITATIONS IN CENTRIFUGE-SIMULATED SPACEFLIGHT

Quinn Dufurrena<sup>1</sup>, Allison S. Burrell<sup>2</sup>, Rebecca Blue<sup>1</sup>, Michael Harrison<sup>3</sup>, Ronak Shah<sup>1</sup>, Serena Aunon-Chancellor<sup>1</sup>, William Powers<sup>1</sup>  
<sup>1</sup>UTMB, Galveston, TX, United States; <sup>2</sup>No affiliation, Washington, DC, United States; <sup>3</sup>Axiom Space, Inc., Houston, TX, United States

#### (Original Research)

**INTRODUCTION:** The burgeoning commercial space industry has provided the possibility for differently-abled persons to travel to space. As this population includes individuals with functional limitations, there is a need to evaluate safety, operational performance, and accommodation of medical and physiological limitations in spaceflight environments. Early study has demonstrated feasibility of accommodation of broader physiological abilities in microgravity; however, spaceflight stressors are more broad and involve hypergravity transitions and other physical stressors. Such factors must be evaluated to determine the comprehensive impact of physical and environmental challenges on those with differing physical needs. We present two cases of individuals with mobility limitations participating in centrifuge-simulated spaceflight. **METHODS:** Two subjects volunteered to participate in human centrifuge research at the National Aerospace Training and Research Center (NASTAR). Subjects included a 69yo female with limited ambulatory ability (bilateral knee replacement, spinal arthritis, partial blindness, use of mobility aid) and a 40yo female with limited mobility requiring crutches (diastematomyelia, central syrinx, lower extremity partial paralysis, multiple and recent surgeries). Subjects were given the opportunity to participate in multiple centrifuge runs simulating commercial

spaceflight. Maximum exposures included  $+4.0G_z$ ,  $+4.5G_x$ ,  $6.1G$  resultant, and maximum onset rate  $<0.5G_z/\text{sec}$  and  $\leq 1G_x/\text{sec}$ . The 69y subject additionally participated in stepwise  $+G_x$  and  $+G_z$  familiarization exposures. **RESULTS:** Participants demonstrated variable tolerance to centrifugation. Both subjects experienced challenges entering and exiting the gondola and required assistance in this process. One subject (40y) successfully completed all centrifuge profiles; the second (69y) reported chest discomfort during familiarization  $+G_x$  exposures and declined further participation. Subjects experienced no adverse physiological outcomes related to centrifuge exposure. **DISCUSSION:** Accommodation of varied physical abilities is an important step in the development of the commercial spaceflight industry. Consideration must be given to vehicular mobility requirements, hypergravity stressors, and physical requirements associated with operational or contingency actions. Ultimately, accommodation of differing physical needs is possible with appropriate design and operational modifications.

#### Learning Objectives

1. The physiologic stressors of spaceflight can be tolerated by differently-abled persons and those with physical limitations.
2. Design considerations and operational modifications may be necessary to accommodate those with limitations in the spaceflight environment.

#### [88] NEUROVESTIBULAR DYSFUNCTION IN CENTRIFUGE-SIMULATED COMMERCIAL SPACEFLIGHT

Kristi Ray, Rebecca Blue, Karen Ong, Serena Aunon-Chancellor, Ronak Shah, William Powers  
 UTMB, Galveston, TX, United States

#### (Original Research)

**INTRODUCTION:** With increasing commercial access to space, the subjective experience of potential customers or spaceflight participants is of particular interest. Neurovestibular disorientation symptoms, including vertigo and motion sickness, are subjectively unpleasant and can lead to physical hazards including emesis or operational performance impacts. Individuals with preexisting neurovestibular conditions may be predisposed to discomfort or more serious sequelae; however, such individuals may still pursue commercial spaceflight opportunities. Here we present a case series of three individuals with various neurovestibular disorders experiencing centrifuge-simulated spaceflight. **METHODS:** Three subjects with a history of neurovestibular dysfunction volunteered to participate in ongoing human centrifuge research at the National Aerospace Training and Research Center (NASTAR). Subjects included a 55y female with a history of Meniere's disease, a 30y female with a history of recurrent barotrauma and resultant vestibular imbalance, and a 69y female with a history of vestibulo-ocular impairment. Subjects were given the opportunity to participate in up to five centrifuge runs in an 8-hour period, with profiles simulating commercial spaceflight. Maximum exposures included  $+4.0G_z$ ,  $+4.5G_x$ ,  $6.1G$  resultant, and maximum onset rate  $<0.5G_z/\text{sec}$  and  $+1G_x/\text{sec}$ . Physiologic data included hemodynamics, neurovestibular exams, and post-run symptom questionnaires. **RESULTS:** The participants demonstrated variable tolerance to centrifugation. Hemodynamic parameters remained within expected ranges compared to an age-matched cohort. However, all three subjects opted out or reduced intensity of one or more of the centrifuge experiences, citing dizziness and motion sickness as factors driving them to limit their experience. In follow up, subjects experienced no adverse physiological outcomes related to centrifuge exposure. **DISCUSSION:** In centrifuge analog, individuals with neurovestibular dysfunction demonstrated symptoms ranging from anxiety related to their concern regarding their own performance to frank vomiting. In an operational environment, symptom exacerbation may ultimately pose a risk to spaceflight activities, as individuals suffering from neurovestibular dysfunction may find themselves incapacitated during critical operational periods such as dynamic flight phases. Further study of mitigation techniques, desensitization, and pharmacological solutions is warranted.

**Learning Objectives**

1. The audience will learn about the relationship between neurovestibular dysfunction and symptoms during analog spaceflight.
2. The participant will be able to understand the physiologic changes that occur in those undergoing analog spaceflight with neurovestibular disorders.

### [89] INVERSION DISORIENTATION INDUCED BY CENTRIFUGE-SIMULATED CAPSULE ABORT ACCELERATION

Rebecca Blue<sup>1</sup>, Karen Ong<sup>1</sup>, Michael Harrison<sup>2</sup>

<sup>1</sup>UTMB, Galveston, TX, United States; <sup>2</sup>Axiom Space, Inc, Houston, TX, United States

(Original Research)

**INTRODUCTION:** Spaceflight-analog environments are known to be invaluable for the screening and preparation of individuals prior to actual spaceflight experience. High-fidelity centrifuge simulation is standard for the training of career astronauts; in the commercial industry, human centrifuge training has similarly been used for training before commercial spaceflight participation. However, centrifugation is an imperfect analog. Centrifuge motion may cause motion sickness or spatial disorientation that could have an adverse training effect or result in a negative experience. Here we will discuss spatial disorientation experienced as an enhanced inversion sensation by layperson participants in a centrifuge-simulated capsule launch abort. **METHODS:** Volunteer subjects participated in a simulated capsule launch with abort and activation of a launch escape system, with dynamic cycling of +G<sub>x</sub> and oscillatory multiaxis exposures simulating parachutes and water landing. Subjects were primarily maintained in ~0° body positioning for non-acceleration periods but were exposed to transient -G<sub>z</sub> (mean -0.2G<sub>z</sub> (-13°) with each acceleration sustained <5sec) during simulated drogue deployments. Subjects were asked to report any inversion sensation; following completion, subjects indicated perceived body positioning on polar coordinates. **RESULTS:** Subjects universally reported a sensation of body inversion generally exceeding the actual body positioning within the capsule (average -42°). Onset correlated with simulated drogue deployment and persisted through much of the simulated descent, beyond the time at which subjects had returned to 0° positioning. Subjects that were prewarned about the potential illusion demonstrated improved subjective tolerance of the profile compared to those without advance warning. **DISCUSSION:** Classic inversion illusions are somatogravic illusions most commonly experienced during +G<sub>x</sub> acceleration accompanied by sudden alterations of pitch. In this case, the illusion is thought to be most likely induced by the flat to transient head-down position exacerbated by rapid cycling of +G<sub>x</sub> acceleration and multiaxis oscillation (including pitch alterations). The ubiquitous experience of the illusion highlights the potential for disorientation in a centrifuge analog; further, this highlights the need for export review of analog profiles to identify illusions. Inadequate preparation could result in aversion to other spaceflight or analog experiences.

**Learning Objectives**

1. The audience will learn about the classic somatogravic inversion illusion and a unique inversion illusion experienced during centrifuge-simulated spaceflight.
2. The audience will learn about the variable tolerance of individuals trained regarding potential illusion vs. those without advance warning.

Monday, 05/22/2023  
Nottoway & Oak Alley

2:00 PM

### [S-17]: SLIDES: CLINICAL CONSIDERATIONS IN AEROSPACE MEDICINE

Chair: Elisabeth Eekhoff

Co-Chair: Steve Vander Ark

### [90] DIAGNOSTIC PERFORMANCE OF CT FRACTIONAL FLOW RESERVE IN ADDITION TO CT CORONARY ANGIOGRAPHY IN PATIENTS, PILOTS, AND ASTRONAUTS

Paul Martin Bansmann<sup>1</sup>, Hans-Jürgen Nobl<sup>2</sup>, Nadine Mühlbauer<sup>2</sup>, Ehling Josef<sup>2</sup>, Lennard Ostrop<sup>2</sup>

<sup>1</sup>Hospital Porz am Rhein, Cologne, Germany; <sup>2</sup>Department of Imaging Diagnostics, German Air Force Centre for Aerospace Medicine, Cologne, Germany

(Original Research)

**INTRODUCTION:** Heart disease is the major cause of disease related death in western civilized populations as well as in pilots and astronauts worldwide. Coronary artery disease (CAD) is found in 85% of pilot autopsies after fatal accidents [1-3]. CAD screening standards vary widely among different aviation organizations. With increasing mean age of active pilots early diagnosis and risk stratification of CAD is crucial. AI-based CT fractional flow reserve (FFRCT) is a physiologic simulation technique that models coronary flow from routine coronary CT angiography (CTA) and has been introduced in Germany in 01/2022. The diagnostic performance of CT fractional flow reserve (CT-FFR) in addition to CT coronary angiography (CTCA) is being examined. **METHODS:** A retrospective case review was carried out for the first 120 consecutive German patients (39 female, 81 male) with a mean age of 62 ± 8 years at Hospital Porz am Rhein, Cologne, Germany, who had CTCA on a 256-slice CT System (GE Revolution Apex) and CT-FFR analysis (HeartFlow, Redwood City, CA) between January and September 2022. **RESULTS:** Patients with CT-FFR > 0.8 were significantly less likely to require further examinations with coronary angiography (p: < 0.00001) than those with CT-FFR < 0.8. The use of CT-FFR significantly reduced need for further functional imaging (8% vs. 14%) (p: 0.00012). A strong correlation was found in a total of 7 patients who had both CT-FFR and invasive FFR. **DISCUSSION:** This retrospective study demonstrates that the additional use of CT-FFR significantly reduces the need for invasive coronary angiography in patients with CT-FFR > 0.8 and also reduces the need for further functional testing. In an aging pilot/astronaut population with increasing prevalence of CAD additionally derived functional information can support risk stratification. Randomized prospective multicenter studies are needed to further examine the strong correlation of CT-FFR and invasive FFR.

**Learning Objectives**

1. Understanding of new AI-based CT derived fractional flow reserve in correlation with invasive catheter based fractional flow reserve.
2. Relevance of coronary artery disease in patients, pilots, and astronauts as well as its non-invasive diagnostic, with regard to clinical outcome.

### [91] SENSITIVITY AND POSITIVE PREDICTIVE ACCURACY OF EXERCISE ELECTROCARDIOGRAPHY TEST AMONG AIRMEN IN INDONESIA

Inne Yuliatwati<sup>1</sup>, Reynold Agustinus<sup>2</sup>, Ferdi Afian<sup>1</sup>, Dasti Anditirina<sup>1</sup>

<sup>1</sup>Faculty of Medicine Universitas Indonesia, DKI Jakarta, Indonesia; <sup>2</sup>Aviation Medical Center, DKI Jakarta, Indonesia

(Original Research)

**INTRODUCTION:** Inflight incapacitation due to cardiovascular disease may be insidious, thus an early detection for subtle cardiovascular disease is required for airmen. Exercise electrocardiography (ECG) test is one of the less invasive predictors for the presence of coronary artery disease with sensitivity 60 to 70 percent. The aim of this study is to investigate the sensitivity and positive predictive accuracy of exercise ECG among airmen in Indonesia. **METHODS:** The data were collected from medical records at Aviation Medical Centre, Indonesia, from December 1<sup>st</sup> 2019 until 28<sup>th</sup> February 2022. Subjects were 1<sup>st</sup> class medical certificate airmen who underwent exercise ECG test while conducting routine medical assessment. The exercise ECG test were performed using approved wireless testing system devices, to complete three stages of Bruce protocol for at least nine minutes or to achieve an oxygen uptake equivalent

to 11 metabolic equivalents (METs). Subjects were divided into negative response test and positive/suggestive positive response test. We investigated the specificity and positive predictive accuracy for subtle coronary artery disease. Data were analyzed using SPSS. **RESULTS:** From the 1559 subjects that underwent exercise ECG, 1360 subjects had negative stress test, 196 subjects had positive or suggestive positive stress test and 3 subjects had inconclusive results. The result showed 14 subjects from negative stress test result who had history of coronary artery disease, and 31 subjects from positive stress test who had no coronary stenosis result. The sensitivity from exercise ECG was 92.2 percent and positive predictive accuracy from the subjects was 84.2 percent. **DISCUSSION:** The sensitivity and Positive predictive Accuracy of exercise ECG test at Aviation Medical Center in Indonesia was higher than the predictive capability in detecting subtle coronary artery disease. It detected higher percentage of subjects with coronary artery disease. Completing at least three stages of Bruce protocol for at least nine minutes or achieving an oxygen uptake equivalent to 11 metabolic equivalents (METs) was suggested to be applied in conducting exercise ECG as a predictor for coronary heart disease.

#### Learning Objectives

1. The audience will learn about the diagnostic value of exercise ECG that has been conducted in The Aviation Medical Centre as a predictor for coronary heart disease among pilots in Indonesia.
2. The audience will learn about the specificity of exercise ECG that has been conducted in The Aviation Medical Centre and its importance as a predictor for coronary heart disease among pilots in Indonesia.
3. The audience will learn about the positive predictive value of exercise ECG that has been conducted in The Aviation Medical Centre and its importance as a predictor for coronary heart disease among pilots in Indonesia.

#### [92] SURVEILLANCE AND CERTIFICATION OUTCOMES AFTER MYOCARDIAL INFARCTION OR CORONARY REVASCULARIZATION IN U.S. FIRST-CLASS PILOTS

Rahul Suresh<sup>1</sup>, Rebecca Blue<sup>2</sup>, Charles Mathers<sup>3</sup>, Leigh Speicher<sup>4</sup>, Thomas Flipse<sup>4</sup>, Ann Noris<sup>3</sup>, Valerie Skaggs<sup>3</sup>

<sup>1</sup>NASA, Houston, TX, United States; <sup>2</sup>UTMB, Galveston, TX, United States;

<sup>3</sup>FAA, Oklahoma City, OK, United States; <sup>4</sup>Mayo Clinic, Jacksonville, FL, United States

#### (Original Research)

**INTRODUCTION:** Myocardial infarction (MI) and coronary revascularization are considered disqualifying for certification by the Federal Aviation Administration (FAA). However, pilots demonstrating adequate disease control on follow-up surveillance coronary angiography (CA) and myocardial perfusion imaging (MPI) may be eligible for a Special Issuance (SI) of a First-Class Medical Certificate (FCMC). The objectives of this study were to determine certification outcomes in pilots after an index cardiac event based on a retrospective chart review of FAA case records. **METHODS:** Clinical and demographic data, results of surveillance MPI and CA following the initial event, consult reports from the treating cardiologist, and FAA consultant or panel review and recommendations were reviewed to determine outcomes of certification in those pilots holding a FCMC that developed a first time MI or after revascularization between 2005-2009 and 2013-2015. National Death Index and the FAA inflight incapacitation database were reviewed to ascertain mortality statistics and inflight incapacitation events. **RESULTS:** A total of 660 pilots met inclusion criteria of which 571 submitted all follow-up documentation. Most pilots successfully pursued an SI. Prognostic factors associated with likelihood of successful SI and time to issuance included lower extent and severity of coronary disease, fewer comorbidities, and favorable findings on initial follow-up testing. Data on incidence of symptomatic events, asymptomatic disease recurrence, inflight incapacitation, and mortality were also identified. **DISCUSSION:** In most cases, those pilots who submitted all required medical records in the appropriate follow-up time frames were found to be qualified for an SI of FCMC. Although the FAA requires additional testing and evaluation for certification compared to current clinical treatment standards, this approach aligns with the FAA's

mandate to protect public safety by ensuring pilots remain at low risk for sudden or subtle incapacitation during piloting activities.

#### Learning Objectives

1. Understand how current FAA evaluation requirements for special issuance after an acute coronary event differ from established clinical guidelines.
2. Describe those prognostic factors that are associated with increased likelihood of a successful special issuance after myocardial infarction or revascularization.

#### [93] THE EFFECT OF HYPERBARIC OXYGEN THERAPY ON BLOOD PARAMETERS AND BIOCHEMICAL MARKERS IN PATIENTS WITH DIABETIC FOOT

Erdinc Ercan<sup>1</sup>, Gamze Aydin<sup>1</sup>, Bulent Erdogan<sup>2</sup>

<sup>1</sup>University of Health Sciences, Ankara, Turkey; <sup>2</sup>Gulhane Training and Research Hospital, Ankara, Turkey

#### (Original Research)

**INTRODUCTION:** Diabetes is a metabolic disease with a high morbidity and mortality and increasing in prevalence all over the world. Diabetic foot is the most common complications of diabetes caused by the combined effect of diabetes-related vascular disease and neuropathy. Hyperbaric Oxygen Therapy (HBOT) increases angiogenesis, fibroblast proliferation and activity of leukocytes, while reduces tissue edema and suppresses the inflammation. Because of these positive clinic and physiological outcome of this treatment, HBOT has been used as an adjunct treatment for diabetic foot ulcers for many years. The purpose of this study was to evaluate effects of HBOT on blood parameters and biochemical markers in patients with diabetic foot. **METHODS:** Patients who applied to the Yunus Emre State Hospital's Hyperbaric Oxygen Treatment Center between September 1, 2016, and December 31, 2020, and received HBOT with a diagnosis of a diabetic foot disease constituted the study group. Patients' files were analyzed retrospectively, and files did not include results of the blood assays taken both before and after HBOT were excluded from the study. **RESULTS:** 103 male and 36 female patients' files analyzed within the scope of this study. There was no statistical significance between genders in the parameters of age, total number of the HBOT sessions, elapsed time of the blood tests taken before and after HBOT. In men group, WBC, Neutrophil, Monocyte, PLT, and PCT levels decreased ( $p < 0.05$ ), and an increase in LYM, EOS, MCHC, and RDW levels were detected ( $p < 0.05$ ) after the treatments. Female patients had lower WBC, neutrophil, PLT, and PCT values ( $p < 0.05$ ) after the HBOT. A decrease in the glucose and CRP levels were detected after HBOT ( $p < 0.05$ ) in both genders. No clinically significant results were founded in the levels of the blood lipid profile, and markers of kidney & liver functions in both genders. **DISCUSSION:** In our hospital, a multidisciplinary treatment approach is used to treat diabetic wound patients, and it has been determined that HBOT applied adjunct to the medical and surgical treatments has positive effects on the blood parameters and inflammatory markers.

#### Learning Objectives

1. The participant will be able to understand physiology of Hyperbaric Oxygen Therapy.
2. The audience will learn about positive effects of Hyperbaric Oxygen Therapy in diabetic foot ulcers.
3. The audience will learn about effects of Hyperbaric Oxygen Therapy on blood parameters.

#### [94] OSTEOPETROSIS IN A MILITARY HEAVY PILOT: A CASE REPORT

Cody Hedrick, Luke Menner

USAFSAM, Wright-Patterson AFB, OH, United States

#### (Education - Case Study)

**INTRODUCTION:** This case report describes a military heavy pilot who was diagnosed with autosomal dominant osteopetrosis type II. **BACKGROUND:** Autosomal dominant osteopetrosis (ADO) type II is a rare skeletal dysplasia characterized by increased bone density caused

by a heterozygous pathogenic variant CLCN7 gene. Complications result from increased bone thickening and abnormal architecture. Clinical manifestations include degenerative arthritis, cranial neuropathies (e.g., optic or auditory), increased fracture risk of ribs or long bones (e.g., femur), cytopenias (e.g., anemia), and disruptions in calcium homeostasis. Such complications may have a significant impact on flight safety.

**CASE PRESENTATION:** A 30-year-old male USAF military heavy pilot was evaluated for left knee pain. There were no preceding injuries or chronic musculoskeletal-related conditions. Initial radiographs revealed bone thickening in a sclerotic pattern concerning for osteopetrosis. Further radiographic imaging via skeletal survey demonstrated diffuse calvarial thickening and sclerosis, sclerotic vertebral endplates, and diffuse pelvic and hip bone sclerosis concerning for ADO. Genetic testing revealed a heterozygous pathogenic variant mutation in the CNCL7 gene, confirming the diagnosis. Brain and orbital MRI revealed mild calvarial thickening but without evidence of osseous crowding of the orbits, orbital canals, or auditory canals. Laboratory testing was without evidence of abnormal calcium-homeostasis. Audiology and extensive ophthalmologic evaluation were normal. Member was returned to flight status with restriction from ejection seat platforms. **DISCUSSION:** This case highlights multiple flight safety concerns. Degenerative arthritis may result in physical impairments that negatively impact performance or hinder emergently egressing an aircraft. Certain aviation environments may increase the likelihood for sustaining pathologic fractures. Abnormal bone architecture in the skull may result in cranial nerve impingement resulting in visual and auditory impairments. Complications such as anemia (secondary to bone marrow encroachment) can negatively impact performance and G-tolerance. The aeromedical community must be cognizant of ADO's associated complications in order to mitigate aeromedical risk by periodic laboratory monitoring, annual audiology and ophthalmologic evaluations, and appropriate occupational restrictions if indicated.

#### Learning Objectives

1. The aeromedical community will better understand the pathophysiology and associated complications of autosomal dominant osteopetrosis.
2. The aeromedical community will be equipped with mitigation strategies to reduce or detect complications of autosomal dominant osteopetrosis that pose a flight safety risk.

#### [95] RISKS OF INCREASED EARTH INDEPENDENCE

Alonso Vera, Kaitlin McTigue, Tina Panontin, Megan Parisi, Shuchieh Wu

NASA Ames Research Center, Mountain View, CA, United States

(Original Research)

As human space exploration begins to extend beyond the immediate vicinity of Earth, the ability of expertise on the ground to support operations will progressively decrease. Ground control expertise has been the primary countermeasure preventing loss of life and mission over the past sixty years and it will be gradually stripped away as expeditions reach further into space. The large, flexible and adaptive teams of experts on the ground, provide not only engineering analysis and problem-solving but also greatly increased work capacity. Monitoring of the large and fast moving stream of telemetry data is carried out around the clock by 20-30 flight controllers per shift. Analysis of that data and troubleshooting is carried out by an additional 50-100 engineers per shift. Artificial intelligence capabilities will need to be part of the solution but will not be the entire solution. As progress continues to be made on intelligent systems, especially those for use in complex, dynamic environments where humans will remain a part of the activity, there is an ever increasing need to focus on how those systems will interact with the humans. Although capabilities such as natural language processing and facial recognition have become common place, even basic aspects of problem-solving, causal reasoning and generative decision-making remain well-beyond of our current capabilities. Advanced data visualization, procedure execution support, and new training approaches will be needed to close the gap between what is currently provided by experts on the ground

and what the crew will need to do in increasingly autonomous ways with greater distance from Earth.

#### Learning Objectives

1. The audience will learn about the new challenges facing human space exploration beyond low-Earth orbit as ground support decreases due to communication, resupply and evacuation challenges.
2. The audience will learn about the human research and technology roadmaps being pursued to close the gaps introduced by decreased ground support for missions beyond low-Earth orbit.

Monday, 05/22/2023  
Grand Ballroom A-B-C

4:00 PM

### [S-18]: PANEL: THE SPACEX INSPIRATION4 MISSION: RESULTS OF THE MOST COMPREHENSIVE MULTISCALE OMICS PROFILING OF SHORT-DURATION SPACEFLIGHT TO DATE

Chair: Michael Schmidt

**PANEL OVERVIEW:** The SpaceX Inspiration4 mission conducted in 2021 presented an opportunity for extensive biospecimen collection in order to study the impact of spaceflight on the human body (N=4). Biospecimen samples were collected from the crew before (L-92, L-44, L-3 days), during (FD1, FD2, FD3), and after (R+1, R+45, R+82, R+194 days) spaceflight in order to create a longitudinal sample set. These samples included blood from venipuncture, dried blood spot cards, saliva, urine, stool, microbiome body swabs, capsule swabs, and skin biopsies. Blood was further processed to obtain aliquots of serum, plasma, extracellular vesicles, and PBMCs. One study objective was to establish a foundational set of methods for biospecimen collection on commercial spaceflight missions that are suitable for multi-scale omics analysis and translational across different missions. A second objective was to conduct the most extensive untargeted multi-scale omics profiling effort to date (genome, transcriptome, proteome, metabolome, skin microbiome, etc.) of short-duration orbital human spaceflight. This was done in order to develop a more complete catalog of human molecular and cellular responses to short-duration spaceflight. This panel will review some of the novel molecular and cellular patterns identified during the mission. It will also explore the complexities of such comprehensive biospecimen sampling and analysis, lessons learned from the all-civilian crew, future directions aimed at refining these methods, and its potential implications for precision medicine.

#### [96] A COMPREHENSIVE REPORT OF ALL BIOSPECIMENS AND MULTI-OMIC MEASUREMENTS FROM THE INSPIRATION4 MISSION

Elijah Overbey<sup>1</sup>, Krista Ryon<sup>1</sup>, JangKeun Kim<sup>1</sup>, Julian Schmidt<sup>2</sup>, Caleb Schmidt<sup>2</sup>, Sunny Narayanan<sup>3</sup>, Chris Mason<sup>1</sup>

<sup>1</sup>Weill Cornell Medicine, New York, NY, United States; <sup>2</sup>Advanced Pattern Analysis & Countermeasures Group, Boulder, CO, United States; <sup>3</sup>Florida State University College of Medicine, Tallahassee, FL, United States

(Original Research)

**INTRODUCTION:** The commercial spaceflight sector is entering a renaissance, with renewed interest in crewed missions. In order to leverage these crewed spaceflight opportunities for understanding the impact of spaceflight on the body, the standard omics measures for astronauts (SOMA) initiative was created. During 2021, the crew of the Inspiration4 mission became the first participants in SOMA, an initiative which will continue for future crewed missions. In this talk, we will present the spectrum of biospecimen samples collected, the breadth of omics assays that were performed, and lessons learned for improving sample collection both on the ground and in microgravity. **METHODS:** Biospecimen samples were collected from the crew before (L-92, L-44, L-3

days), during (FD1, FD2, FD3), and after (R+1, R+45, R+82, R+194 days) spaceflight in order to create a longitudinal sample set. These samples included blood from venipuncture, dried blood spot cards, saliva, urine, stool, microbiome body swabs, capsule swabs, and skin biopsies. Blood was further processed to obtain aliquots of serum, plasma, extracellular vesicles, and PBMCs. **RESULTS:** Over 2000 sample aliquots were collected throughout the duration of the study. Omics assays performed include whole genome sequencing, direct RNA-seq, spatially resolved transcriptomics, single-cell RNA-seq, single-cell ATAC-seq, T-cell and B-cell immune repertoire sequencing, metagenomics, and metatranscriptomics. **DISCUSSION:** The objective of this project was to establish a foundational set of biospecimens and multi-omic approaches to perform consistently commercial spaceflight crews. This sample collection was a success, but also encountered challenges due to the unique nature of spaceflight studies. Challenges in sample collection include small crew sizes and inconsistent biospecimen collection locations. These issues can be mitigated with biospecimen sampling and protocol standardization. Challenges were also encountered when performing sample collection in microgravity due to differences in fluid dynamics. These changes altered the protocols for skin and capsule swabbing, saliva collection, and dried blood spot card collection during flight. These considerations should be addressed in biospecimen collection for future flights.

#### Learning Objectives

1. The audience will learn what types of biospecimens are collected from commercial astronaut crews.
2. The audience will learn the breadth of multi-omic assays used to study astronaut health.

### [97] A BIOBANK TO SUPPORT THE FEDERATED STUDY OF PRIVATE ASTRONAUTS

Christopher Mason, Eliah Overbey

Weill Cornell Medicine, New York, NY, United States

#### (Original Research)

The New Space Era has expanded participation in crewed missions to include a higher proportion of civilian astronauts. Before July of 2021, only eight civilians had crossed the Kármán Line to view the Earth from space. Since then, 29 private astronauts have launched on a variety of vehicles, built and operated by multiple private companies, to suborbital and orbital destinations. With the prospect of high demand for commercial crewed missions, the ability to support the health and well-being of an increasingly diverse cohort of astronauts is imperative. Catalyzed by the formation of the Inspiration4 mission in 2021, the Space Exploration Company (SpaceX) embarked on a collaboration with investigators at Weill Cornell Medicine, the Translational Institute of Space Health (TRISH), and the University of Southern California to form the first Private Aerospace Biobank. This was the first attempt to collect biological specimens from an exclusively civilian crew on a mission operated entirely by a private launch provider. Over two thousand specimens were collected, including venous and capillary blood, saliva, stool, urine, skin biopsies, and microbial swabs using collection protocols suitable to the mission that were developed in close collaboration with the crew. These longitudinal samples were used for a multi-omic analysis of the crew, including genome, epigenome, transcriptome, proteome, microbiome, metabolome, exosome, telomere, single-cell V(D)J immunophenotyping and epitope maps, and spatial transcriptome analysis. This repository of biobanked specimens collected from the start of training to several months following splashdown, along with raw data, processed data, and metadata, will enable the global spaceflight community a means of studying private astronauts and offer an initial roadmap for specimen collection throughout the commercial space sector.

#### Learning Objectives

1. The participant will be able to list several types of omics protocols and analyses.
2. The audience will learn about the biospecimens that are banked for future research and the analyses that have been performed on the samples collected to date.

### [98] INSPIRATION4: COMPREHENSIVE AND INTEGRATIVE SINGLE CELL MULTI-OMICS ANALYSIS OF THE IMMUNE SYSTEM OF SPACEX INSPIRATION4 MISSION CREWS

JangKeun Kim<sup>1</sup>, Eliah Overbey<sup>1</sup>, Jiwoon Park<sup>1</sup>, Remi Klotz<sup>2</sup>, Veronica Ortiz<sup>2</sup>, Michael Schmidt<sup>3</sup>, Deena Najjar<sup>1</sup>, Krista Ryon<sup>1</sup>, Jaime Mateus<sup>4</sup>, Min Yu<sup>5</sup>, Christopher Mason<sup>1</sup>

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#### (Original Research)

**INTRODUCTION:** Immune dysregulation during spaceflight is a well-known biological change during long and short-duration missions. However, high-resolution, single-cell studies in model organisms exposed to spaceflight are limited and single-cell studies performed on astronauts are scant. In 2021, the SpaceX Inspiration4 mission enabled single-cell multi-omics analysis of four astronauts, which enabled a state-of-the-art, multi-omic, single-cell profiling to address the gaps in our knowledge of the cellular response to space. **METHODS:** To comprehensively monitor and analyze the biological impact of 3-day short-term spaceflight on the astronaut immune system longitudinally, we generated single-cell multi-omics gene expression (GEX), transposase-accessible chromatin accessibility (ATAC), and V(D)J sequencing data from peripheral blood mononuclear cells (PBMCs) across 6 total pre- and post-flight time-points. In addition, we comprehensively analyzed and integrated these multi-omics data with complete blood count (CBC) clinical test results and biochemical profiles. And we integrated single cell PBMC data with plasma proteomics, exosome proteomics, and skin spatial transcriptomics to compare the changes in different samples. **RESULTS:** Across a total of 140,916 cells, we found cell proportion, gene expression, chromatin accessibility, overrepresented DNA motifs in differentially accessible regions, clonal lineage, mutation profile, and trajectory change after spaceflight. Also, we found that those biological changes mostly revert back to normal within a few months after spaceflight. It is noted that immune-related pathways were up-regulated, and oxidative phosphorylation and metabolism-related pathways were down-regulated in most of the subpopulations. And we've found secretome (plasma and serum) responded differently, however, there are common changes between PBMCs and skin transcriptomics. **DISCUSSION:** These data represent the first integrative, single-cell, multi-omics analysis (GEX, ATAC, V(D)J) from an astronaut cohort, which is additionally supplemented with changes with CBC and cytokine measurements. We can leverage these data for future missions and to assist with risk mitigation and countermeasure development.

#### Learning Objectives

1. Understand the overview of single cell multi-omics study of Inspiration4 mission.
2. Understand the biological changes after 3-day space mission with multi-omics perspective.
3. Understand the biological meaning and potential therapeutic approach for the biological change from spaceflight.

### [99] SPATIAL TRANSCRIPTOMICS AND MULTI-OMICS REVEAL HUMAN SKIN RESPONSES TO SPACEFLIGHT

Jiwoon Park<sup>1</sup>, Christopher Mason<sup>1</sup>, Eliah Overbey<sup>1</sup>, Sunny Narayanan<sup>2</sup>, JangKeun Kim<sup>1</sup>, Braden Tierney<sup>1</sup>, Evan Afshin<sup>1</sup>, Krista Ryon<sup>1</sup>, Namita Damle<sup>1</sup>, Deena Najjar<sup>1</sup>, Matthew MacKay<sup>1</sup>

<sup>1</sup>Weill Cornell Medicine, New York, NY, United States; <sup>2</sup>Weill Cornell Medicine, Tallahassee, FL, United States

#### (Original Research)

**INTRODUCTION:** During spaceflight, the human body is exposed to various factors unique to the space environment, and significant physiological adaptations and overall shifts in biological homeostasis

occur. The skin is a key physiological system sensitive to environmental change and serves multiple functions, including physical and immunological protection, microbiota homeostasis, fluid retention; however, only a few studies exist of the spaceflight's impact on the skin, and observations to-date are limited. **METHODS:** We performed 4 mm skin biopsies on the SpaceX Inspiration4 crews before (L-44) and after (R+1) spaceflight and used GeoMx™ Digital Spatial Profiler to quantitatively analyze spatially resolved, whole transcriptome gene expressions across 95 regions of interest and four compartments: outer epidermis, inner epidermis, outer dermis, and vasculature. From the transcript-level findings, we matched metagenomic and metatranscriptomic data from skin swabs obtained prior to biopsy, as well as single-cell sequencing data from isolated Human peripheral blood mononuclear cells. **RESULTS:** We observed the upregulation of genes related to general inflammatory responses and KRAS signaling across all regions in post-flight samples. We located the molecular and cellular microenvironment changes (e.g. interferon responses, DNA damages, epithelial barrier disruption, impaired regeneration) to specific tissue compartments. While all regions show consistent enrichment in inflammation-related pathways, damage and repair pathways were primarily in the outer epidermal regions. We also correlated the epithelial layer disruption with microbe changes from skin swab metagenomics and immune cell (macrophage and T) activation with PBMC single-cell data. **DISCUSSION:** These data represent the first-ever collection and multi-modal analysis of astronaut skin across skin spatial, metagenomic, metatranscriptomic, and single-cell sequencing data. From spatial data, compartment-specific changes in damage/repair-related pathways from the expected stressors and changes occur during spaceflight, primarily in the outermost epidermis and related to epithelial barrier disruption. We correlated some of these molecular changes to previously known and novel skin microbial changes and validated these observations by comparing the immune composition and expression from PBMC data. The findings can inform future mission planning and countermeasures for inflammatory and immune system responses.

#### Learning Objectives

1. The participants will be able to understand the molecular impact of spaceflight on skin tissue
2. The audience will learn about the standardized omics collection approaches for spaceflight samples

### [100] THE METAGENOMIC AND METATRANSCRIPTOMIC ARCHITECTURE OF HUMAN AND SPACECRAFT MICROBIOME ALTERATIONS DURING SHORT-TERM SPACEFLIGHT

Braden Tierney, Chris Mason

Weill Cornell Medical College, New York, NY, United States

(Original Research)

**INTRODUCTION:** The drivers of variation in host-microbe interactions during spaceflight are not fully understood. Given the substantial role both spaceflight and microbes play in altering human physiology, understanding the dynamic interactions therein is of the utmost import. However, identifying how host-microbe relationships change in space has proven difficult due to limited datasets of sufficient sample size.

**METHODS:** During the 2021 Inspiration4 mission we collected the largest-to-date, longitudinal, metagenomic and metatranscriptomic cohort from four individuals before, during, and after spaceflight across a total of 8 timepoints. In total, this dataset comprises 360 samples from 10 human body sites and 10 environmental sites from the Dragon capsule. **RESULTS:** We generated a series of resources for the community, including (1) non-redundant gene catalogs, (2) microbial taxonomic abundances, and (3) functional annotations (i.e., antimicrobial resistance genes) data. We identified the landscape of bacterial and viral activation in flight, noting substantial, pan-phyletic viral activation during flight. We additionally found consistent loss and gain and biomedically relevant microbial taxa before and after flight, indicating potential long-term impacts of space travel on the human microbiome.

Finally, we quantified the nature of inter-individual variation in the host microbiome as a function of environmental (i.e., capsule microbiome) context. **DISCUSSION:** In summary, the consistent variations we observed in this longitudinal data resource indicate the utility of tracking metagenomic data while in space to estimate how its changes may impact astronaut health.

#### Learning Objectives

1. The participant will understand content of the microbiome resource we constructed relating to short-term spaceflight and its long-term impacts.
2. The audience will learn about the composition of and drivers of microbiome (bacterial and viral) shifts during spaceflight and how they may impact host health. We will specifically highlight consistent shifts in bacterial and viral composition that are relevant for human health.

### [101] PROTEOMICS ANALYSIS FROM BLOOD PLASMA AND EXOSOMES OF 14 ASTRONAUTS REVEALS DISTINCT RESPONSES AFTER SPACEFLIGHT

Nadia Hauerbi<sup>1</sup>, Eliah G. Overbey<sup>1</sup>, Jaden J.A. Hastings<sup>1</sup>, Laura Iona Patras<sup>1</sup>, Irina Matei<sup>1</sup>, JangKeun Kim<sup>1</sup>, Aaron S. Gajadhar<sup>2</sup>, Daniel Hornburg<sup>2</sup>, David C Lyden<sup>1</sup>, Jaime Mateus<sup>3</sup>, Christopher E Mason<sup>1</sup>

<sup>1</sup>Weill Cornell Medicine, New York, NY, United States; <sup>2</sup>Seer Inc, Redwood City, CA, United States; <sup>3</sup>SpaceX, Hawthorne, CA, United States

(Original Research)

**INTRODUCTION:** The human body has a broad range of responses to spaceflight, and some of the fastest changes occur in the vasculature, blood, and plasma during the first day in microgravity. Yet, limited data exists about the entire set of proteins (proteome) in blood, and there is almost no data on astronauts' exosome proteome. To address this gap in knowledge, we performed deep quantitative proteome profiling on four astronauts from the Inspiration4 mission, from both before and after flight. **METHODS:** Plasma from 4 astronauts was isolated at 3 timepoints pre-flight (L-92, L-44, L-3 days) and 3 timepoints postflight (R+1, R+45, R+82 days) from cell processing tubes (CPTs) and processed with Seer's Proteograph Analysis Suite. Briefly, Seer's standard 5-nanoparticle panel was used to enrich for low abundance proteins followed by LC-MS/MS proteomics analysis with data-independent acquisition (DIA) strategy. Exosomes were purified from plasma by sequential ultracentrifugation and proteins were isolated and measured with LC-MS/MS. **RESULTS:** We identified a total of 23,164 peptides mapping to 2,992 unique protein groups in the plasma. We compared identified 60 proteins that had significant differences in abundance immediately postflight (R+1) compared to preflight. Longitudinal analysis showed that most proteins return to preflight levels at R+82 while others remain dysregulated at R+82. Gene ontology enrichment analysis for the differentially abundant proteins showed an association with production of reactive oxygen species, collagen and extracellular matrix as well as lipid metabolism and lipoproteins. LC-MS/MS analysis of the isolated exosomes identified a total of 636 unique proteins with an average of 585 proteins per sample. Focusing on proteins differentially packaged immediately post return to Earth, we identified 8 proteins (HAGH, NUTF2, ACHE, ART4, PTPA, MPST, RUVBL1 and LXN) exclusively packaged in exosomes of R+1 samples. When comparing all postflight to all preflight samples, we identified 22 differentially abundant proteins in the exosomes. These proteins showed enrichment for inflammatory and immune response pathways as well as different metabolic pathways. **DISCUSSION:** Our results show that even short duration spaceflight can have a measurable impact on plasma protein abundance and exosome packaging that need further investigation.

#### Learning Objectives

1. The audience will learn about the effect of short-duration spaceflight on plasma proteome and exosomal proteome and which pathways are most affected by short-duration spaceflight.

- The audience will learn about the effect of short-duration of spaceflight on the plasma metabolome and examine what the main metabolic changes that occur are.

**Monday, 05/22/2023**  
**Grand Ballroom D-E**

**4:00 PM**

## **[S-19] PANEL: THE RISK MANAGEMENT IN AVIATION MEDICINE**

*Sponsored by SOFRAMAS*

**Chair: Olivier MANEN**

**Co-Chair: Jonathan Monin**

**PANEL OVERVIEW:** *The first objective of aeromedical examiners (AME) working alone or being part of aeromedical centers (AeMC) is to make a decision for every kind of health problem and every type of aircrew specialty. AME should not be attempted to declare someone fit to fly too rapidly, but also unfit too easily as an excessive way of management, all the more as there are professional constraints to take into consideration: military aircrews are frequently working in tense operational circumstances including high level of qualification and overseas deployments, and civilian aircrews have commercial and financial constraints that have not decreased in the post-Covid context with a present wish or a need to recover the same flying activity as in 2019. All these professionals do not hesitate to make pressure on their AME during the time of periodical examinations. As a consequence, in the continuation of progress in medicine, it is a necessity that AME regularly question themselves about their aeromedical practice, including for health problems that could be considered as well known and so well managed. Key elements to consider include the evolution in the diagnostic and therapeutic methods, the new medications and the increasing part of instrumental technics particularly, sometimes a change in the philosophy of expertise and potentially new risks to imagine. In this context, this panel will present the updated management of different situations which are part of the daily activity of AME in Percy AeMC: kidney stone disease, atrial fibrillation, self-medication, vestibular disorders, and psychological troubles in UAV pilots.*

## **[102] FLIGHT SAFETY RISK ASSESSMENT OF SELF-MEDICATION AMONG FIGHTER PILOTS**

Thomas Chiniard<sup>1</sup>, François Guénot<sup>2</sup>, Elise Dib<sup>3</sup>, Mathilde Du Baret de Limé<sup>4</sup>, Sébastien Bisconte<sup>5</sup>, Olivier Manen<sup>5</sup>, Jonathan Monin<sup>5</sup>

<sup>1</sup>Bégin Military Hospital, Saint-Mandé, France; <sup>2</sup>Nuclear Missile Submarines Squadron, Brest, France; <sup>3</sup>1st Medical Center, Vincennes, France; <sup>4</sup>Legouest Military Hospital, Metz, France; <sup>5</sup>Percy Aeromedical Center, Clamart, France

*(Original Research)*

**INTRODUCTION:** Fighter pilots are a specific population in which any adverse drug reaction (ADR) can interact with aeronautical constraints in unpredictable ways. Hence, self-medication may compromise flight safety. However, data on this issue are scarce and have never been considered from the perspective of a risk assessment process. This study aimed at providing a semi-quantitative evaluation of the risk to flight safety of self-medication in fighter pilots. **METHODS:** This was an ancillary study of a cross-sectional survey that aimed at identifying the determinants of the practice in this population. A pre-specified secondary objective was to list all medications reported to have been consumed in the 8 hours preceding a flight. Using a modified healthcare Failure Mode and Effects Analysis process, any ADR reported in the French marketing authorization of a drug was considered as a failure mode. The likelihood and presumed impact were evaluated using specific scales to assign each of them to three risk criticality categories: acceptable, tolerable, and unacceptable.

**RESULTS:** Of the 170 fighter pilots who responded to the initial study, 78 reported having ever used self-medication in the 8 hours preceding a flight. Thirty-nine different drug trade names, encompassing 48 different international nonproprietary names, were listed. A total of 107 different semantic groups of ADRs were identified, for a total of 694 ADRs. The risk criticality was considered unacceptable for 10 ADRs from 6 different drugs, tolerable for 152 ADRs from 31 different drugs, and acceptable in the remaining cases. **DISCUSSION:** This analysis suffers from numerous limitations. First, the retrospective, declarative and non-dedicated design of the study introduces many biases. Second, the data collection from the marketing authorizations often fails to provide a robust assessment of ADR frequency "in real life". Third, the qualification of ADR severity still relies on experts' opinions rather than objective criteria. Fourth, the 8 hours time frame before a flight may not be relevant, depending on the drug. Nevertheless, this is the first attempt to provide a semi-quantitative evaluation of the risk to flight safety of self-medication in fighter pilots. This analysis suggests that the overall risk may be tolerable.

### **Learning Objectives**

- This study proposes a modified healthcare Failure Mode and Effects Analysis process to evaluate the risk to flight safety of self-medication in fighter pilots.
- This analysis suggests that the risk to flight safety of self-medication in fighter pilots may be tolerable.

## **[103] RISK ASSESSMENT IN AVIATION WHEN A VESTIBULAR PATHOLOGY OCCURS: THE IMPORTANCE OF EQUITEST.**

Salomé Marty

Percy Military Hospital Aeromedical Centre, Clamart, France

*(Education - Tutorial/Review)*

**INTRODUCTION:** Equilibration is a multimodal function based on information given by 3 sensorial systems: vision, proprioception and vestibule in the terrestrial referential. Vestibular nuclei integrate this information, and analysis occurs in vestibular centers in the cortex. When information matches, spatial orientation is possible without dizziness or instability. In a plane, the sensorial system is based on the plane and not on the terrestrial environment. Because of this different referential, sensorial illusions will be able to happen with spatial disorientation. Therefore, it is essential that aircrew member have a good equilibration function.

**TOPIC:** Equitest, computerized dynamic posturography is the only test permitting the study of the 3 sensorial pieces of information used for equilibration. It allows paraclinical evaluation of equilibrium disorders, diagnosis, and reeducation orientation. It is a test rarely used in France; it is only used in ENT service in the Percy aeromedical center (AeMC Percy). When a patient describes dizziness or instability or presents a vestibular dysfunction, Equitest is essential to evaluate compensation strategies.

**APPLICATION:** Our study encompasses all aircrew members with vestibular disease necessitating Equitest realization between 2014 and 2022 for aptitudes in AeMC Percy (vestibular schwannoma, vestibular neuritis, superior canal dehiscence syndrome). Some patients were temporarily prohibited to fly because of initial pathological Equitest results. After vestibular reeducation, Equitest results normalized allowing for positive aptitude files. In all cases presented to the commission with normal Equitest results, aircrew members were able to obtain for flight aptitude sometimes without limitation. Our presentation will be illustrated with demonstrative clinic cases. **RESOURCES:** Voorhees RL. The role of dynamic posturography in neurotologic diagnosis. Laryngoscope. 1989 Oct;99(10 Pt 1):995-1001.

### **Learning Objectives**

- The audience will learn about importance of vestibular function for aircrew members.
- The audience will learn about the paraclinical exam of vestibular function.

# [104] RISK MANAGEMENT OF KIDNEY STONES IN AVIATION MEDICINE

Jonathan Monin<sup>1</sup>, Gaëtan Guieu<sup>1</sup>, Sébastien Bisconte<sup>1</sup>, Thomas Chiniard<sup>2</sup>, Eric Perrier<sup>1</sup>, Olivier Manen<sup>1</sup>

<sup>1</sup>Aeromedical Center, Percy Military Hospital, Clamart, France; <sup>2</sup>French Military Health Service Academy, Paris, France

(Original Research)

**INTRODUCTION:** The occurrence of renal colic is very frequent in the general population, with approximately 120,000 episodes of renal colic per year in France. For aircrew members, the low hygrometry and the lack of hydration during flight may favor the crystallization of urine in predisposed subjects. In addition, some studies tend to show that accelerations and vibrations could favor stone migration. The occurrence of renal colic in flight is a rare but not exceptional phenomenon, which may jeopardize flight safety in case of in-flight incapacitation, but which may also be a loss of chance for the health of the pilot. Thus, we decided to perform a study to assess the risk management of kidney stones in aircrew members. **METHOD:** This is a retrospective study including all aircrew members with a history of urinary lithiasis at risk of recurrence, who performed a visit in our aeromedical center between 2011 and 2021. We decided to exclude cabin crews in order to have a homogeneous population about consequences on flight safety. Numerous data were collected including flight duty, military/civilian status, lithiasis characteristics (size, localization, symptoms, treatment, recurrence risk factor...) and fitness assessment. The evolution of stones during the follow-up was also studied. **RESULTS:** Nearly one hundred aircrew members were included in this study mostly male, civilian pilots. The fitness assessment is correlated with the recurrence risk assessment, with, for example, a multi pilot limitation and an unfitness for overseas deployments in case of residual kidney stones. Thus, a fit decision is less likely in jet fighter pilots and/or solo pilots. Indeed, renal stone migration or renal colic were not uncommon phenomena in case of residual lithiasis. **DISCUSSION:** The study underlines the logical link between fitness assessment and recurrence risk assessment. Fighter pilots, solo pilots, and military aircrew members who may be deployed overseas are a particular issue in this context. It is important to remember the role of the flight surgeon or the aeromedical examiner in advising aircrews with kidney stones, especially regarding treatment.

## Learning Objectives

1. To know the specific risk factors of renal colic in aircrew members.
2. To understand the elements leading to a fit or unfit decision in aircrew members with kidney stones.

# [105] PSYCHOLOGICAL RISK MANAGEMENT IN REMOTELY PILOTED AIRCRAFT "DRONE" OPERATORS IN THE FRENCH AIR FORCE

Laëtitia Marion<sup>1</sup>, Myriam Leon<sup>2</sup>, Frédérique Gignoux-Froment<sup>3</sup>

<sup>1</sup>Aeronautical Medico-Psychological Department, Percy Military Hospital, Clamart, France; <sup>2</sup>Psychiatry Department, Desgenettes Military Hospital, Lyon, France; <sup>3</sup>Psychiatry Department, Percy Military Hospital, Clamart, France

(Education - Case Study)

**INTRODUCTION:** The first remotely piloted aircraft (RPA) was developed during the First World War by a French engineer and an officer. The need to develop unmanned observation aircraft arose because of the loss of airmen in combats. Today, the French Air Force uses various RPA for intelligence, surveillance and target designation. The most complex missions are carried out with the MQ-9 reaper RPA. In addition to the operators' confrontation with the viewing of violent images, these devices have been armed for several years which could arise the risk for the pilots' mental health. **CASE DESCRIPTION:** Through the experience acquired during the follow-up of crews and the occurrence of a rare aeronautical event, the crash of one of these RPA, during which both individual and collective psychological debriefings were carried out in the

immediate aftermath, we will describe the psychological manifestations that can occur within the crews. We will detail the protective factors we found and also the elements we are looking for in risk management on the medical-psychological level, in particular the elements allowing the early detection of the manifestations of psychological distress, their management and the evaluation of the operational fitness.

**DISCUSSION:** After a serious aeronautical event, anxiety and signs suggestive of a traumatic encounter can appear. Outside this context the disorders most likely to be highlighted are polymorphous and are not necessarily linked to a characterized psychological disorder. On the other hand, these elements must be considered in the context of fitness assessment, in order to avoid a health deterioration of the airman, to preserve group functioning and flight safety. A medico-psychological support is provided by the military health service and the French air force for RPA crews. This dynamic and continuous support begins at the time of their selection, and ends when they leave the army, including training, preparation and return from an operational mission, as well as dealing with any difficulties that may arise during their professional career.

## Learning Objectives

1. To better understand the specific mental health risks in remotely piloted aircraft crews.
2. To underline the need of specific medico-psychological support and fitness assessment in this population.

**Abstract #106** was moved to Poster session: Clinical Medicine & Safety, Thursday, May 25, at 10:00 AM in Nottoway and Oak Alley.

# [107] IMPACT OF MODERN MANAGEMENT OF ATRIAL FIBRILLATION ON THE DECISION-MAKING PROCESS IN AIRCREW

Olivier Manen<sup>1</sup>, Anthony Delalande<sup>2</sup>, Jonathan Monin<sup>1</sup>, Gaëtan Guieu<sup>1</sup>, Jean-François Oliviez<sup>1</sup>, Caroline Brescon<sup>1</sup>, Sébastien Bisconte<sup>1</sup>, Eric Perrier<sup>1</sup>

<sup>1</sup>Percy Military Hospital Aeromedical Centre, Clamart, France; <sup>2</sup>Bégin Military Hospital, Saint-Mandé, France

(Original Research)

**INTRODUCTION:** Atrial fibrillation (AF) is the most frequent sustained arrhythmia. Previous studies had shown a young age in the French aircrew hospitalized for AF. The flight safety may be jeopardized and +Gz accelerations can act as a modulating factor of recurrence. However, the last decade has shown in Europe an increasing place of direct oral anticoagulants and ablation procedures in care medicine, the acceptance of anticoagulation in the EASA regulations as well. **METHODS:** We present a descriptive observational retrospective study. The inclusion criteria of the cohort were to be an aircrew or ATC, to have presented AF episode(s) from April 2013 to April 2022 and to have been examined in Percy military hospital AeMC after treatment. The main objective was to describe the aircrew population with AF episode(s), to observe the key elements for the final decision and to analyze the impact of operational limitations on the career or the leisure flying activity. The secondary objective was to compare the methods of treatment between aircrew and the general population (including the use of radiofrequency ablation), and to evaluate the impact of modern therapy in the return to flying/working duties. **RESULTS:** Preliminary results show a population of 60 aircrews: 58 men and 2 women, 52 pilots and 8 with other functions, 49 civilian and 11 military individuals. Most of them were experienced aircrews but 17 had less than 1,000 flying hours. The mean age of diagnosis was 55 years old, with no symptom in 60% of cases, and an occurrence at rest for 52 aircrews, during exercise for 7 or during a flight for 1. Investigations were in favor of one etiology for 12 aircrews, predisposing factor(s) for 14 and idiopathic AF for 34. CHA<sub>2</sub>DS<sub>2</sub>-Vasc score (from 0 to 4) was  $\geq 1$  in 55% of aircrews. Seven aircrews recovered a normal rhythm spontaneously, 22 required a cardioversion, 28 were prescribed anti-arrhythmic drugs or betablockers, 4 were initially referred to ablation. Finally, 42% have been

using a long-term anticoagulant treatment. Other results will focus on the decision to return flying solo and/or on high-performance aircrafts by the competent aeromedical authority. **DISCUSSION:** It is important to give information to aircrew with AF about the link between treatment and decision, not to incite to an aggressive treatment but to help them to make the best choice.

#### Learning Objectives

1. To know the determinants of the decision-making process in aircrew suffering from AF.
2. To be aware of the possible impact of modern therapeutic approach in the aeromedical decisions and limitations.

**Monday, 05/22/2023**  
**Grand Chenier**

**4:00 PM**

### **[S-20]: SLIDES: MISC: CANCER RISK, HIV, WAIVERS, DCS, & URTICARIA**

**Chair: Paul Young**  
**Co-Chair: Warren Silberman**

#### **[108] DELIVERING GENETICS AND CANCER RISK ASSESSMENT TO ASYMPTOMATIC, DISEASE-FREE AVIATORS FOR PREVENTATIVE MEASURES**

Halle Lindsay

*David Grant Medical Center, Fairfield, CA, United States*

*(Education - Program/Process Review)*

**BACKGROUND:** Aircrew have an occupational cancer risk due to ionizing radiation exposure, circadian rhythm disruption and air quality. There is a need to mitigate risks through cancer screenings and lifestyle modifications. However, a barrier to genetic cancer risk assessment is delivering information to patients. This presentation will provide aerospace practitioners an approach to genetic counseling and testing to develop countermeasures. **OVERVIEW:** Flight crew are exposed to gamma, x-ray and ultraviolet radiation at aviation altitude. In further investigation, a study found U.S. Air Force (USAF) aviators have increased incidence in testicular cancer, melanoma skin cancer and prostate cancer when compared to other USAF officers. Another study, found higher cancer prevalence of breast, melanoma, and other skin cancers among flight attendants when compared to other participants with the same race and socioeconomic status. Due to occupational cancer risks, there is a need to increase surveillance and modify lifestyles risks among aircrew. For the U.S. general population, the U.S. Preventive Services Task Force recommends certain cancer screening guidelines be based on individual discussion between patient and provider. Therefore, it would be beneficial to enhance cancer screening, identify pre-disposing cancer genes, and encourage lifestyle changes for modifiable risks. The expected gains can be weighed against potential patient anxiety. Effective delivery of information is vital for educating, testing, interpreting results and providing support. There are various models to deliver genetic risk cancer assessment varying in professionals involved and presentation type, such as, group presentation or individual counseling. For the population at-risk, we will provide a group presentation to discuss occupational cancer risks. In addition, there will be an opportunity for genetic testing for the results to guide lifestyle changes. This process will include oncologist and geneticist to advise interpretation of results. **DISCUSSION:** With increased cancer incidence among aircrew, there is importance in cancer surveillance and lifestyle modifications to optimize aerospace medical readiness. These efforts have value in providing a targeted approach to educate and support the aircrew in order to develop countermeasures.

#### Learning Objectives

1. The audience will review the various types of cancer risks associated with aviation.

2. The audience will gain methods to deliver genetics and cancer risk assessment counseling to aviators.

#### **[109] ESTIMATION OF CANCER RISK (SOLID TUMORS) FOR THE ACTIVE CREW MEMBERS OF A MAJOR AIRLINE: A SIMPLE METHOD FOR THE OCCUPATIONAL PHYSICIAN**

Michel Klerlein

*Air France, Roissy Charles de Gaulle, France*

*(Original Research)*

**OBJECTIVES:** To provide an acceptable estimate of incidental cancer risk for a currently working crewmembers population, based on occupational health data available in the intern occupational medicine database. **METHODS:** We used the French incidence data to calculate the expected number of cases in a stable population of about 20,000 flight crews for 20 years, and to estimate the risk by the standardized incidence ratio (SIR) from solid tumor cases reported to the occupational physician. SIRs and their Confidence Intervals were based on the Byar's approximation of the exact Poisson distribution and the Chi square test. The study included 384148 person-years (204,199 women – 179,948 men) from 2000 to 2020, in 7 age groups. 459 solid tumors cancer were reported (283 in women – 179 in men). **RESULTS:** The data were used to calculate the incidence ratio in relation to the French population for a period of 20 years (2001 – 2021) and show an overall under-incidence for the main solid tumors of interest in flight personnel (melanoma - breast cancer - prostate cancer - thyroid cancer). The standardized incidence ratios all remained significantly lower than 1. More precisely, the figures were: For women: 0.47 (All cancer sites) - 0.48 (Breast) - 0.48 (Melanomas) - 0.26 (Thyroid) - 0.33 (Kidneys). For men: 0.36 (All cancer sites) - 0.25 (Prostate) - 0.67 (Melanoma) - 0.47 (Thyroid) - 0.54 (Kidneys). **DISCUSSION:** These reassuring results are biased mainly by the healthy worker effect, and by possible under-reporting, but nevertheless indicate the absence of a clear hazard signal. The main objective of the study is also met, since it demonstrates the possibility of making an acceptable estimate of the incidence ratios thanks to the data published in France which provide estimates of incidence by age group allowing the standardization of our calculations.

#### Learning Objectives

1. Getting knowledge of the level of cancer incidence among active aircrews in a major airline.
2. Understanding a simple method to estimate the standardized incidence ratios and their confidence intervals.

#### **[110] EVIDENCE BASED AEROMEDICAL RISK ASSESSMENT OF CUTANEOUS MELANOMA USING UPDATED STAGE SPECIFIC PROGNOSTIC DATA FROM THE AJCC 8TH EDITION**

Ganesh Anbalagan

*CASA Australia, Canberra, Australia*

*(Education - Program/Process Review)*

**BACKGROUND:** Australia has the highest age standardized incidence rate of melanoma in the world. Although the incidence of melanoma in Australia has increased in the last decade, the melanoma mortality rate has declined recently. As the prognosis of melanoma skin cancer is improving, prognostic data from the current 8th edition American Joint Committee on Cancer (AJCC) international melanoma database was used to estimate the stage-based risk of recurrence and risk of incapacitation for aircrew diagnosed with cutaneous melanoma skin cancer.

**OVERVIEW:** Recent evidence in the literature was reviewed to update the prognostic data on risk of recurrence, sites of recurrence especially the central nervous system as it can present with incapacitating symptoms, and the risk of mortality. The melanoma specific survival data from the International Melanoma Database (AJCC cohort) was used to estimate the annualised risk of mortality, which was used as a surrogate marker for risk of recurrence as the progression free survival or distant metastases

free survival was not available for the larger international melanoma database cohort. One of the key aeromedical concerns of melanoma is its ability to metastasise to virtually any organ or tissue and melanoma has the highest risk of brain metastasis among common solid tumours. As the incidence of brain metastasis increased with the stage and the risk remained elevated in the early years after diagnosis, stage specific 5-year cumulative incidence of CNS metastasis was used to estimate the risk of brain metastases. Brain metastases was given a 100% incapacitation risk weighting in risk of incapacitation estimation. Stage-specific annualised percentage risk of incapacitation for melanoma was calculated as a product of risk of recurrence in each year, risk of brain metastases and weighting factor of 100. **DISCUSSION:** Using the Civil Aviation Safety Authority (CASA) of Australia's acceptable risk threshold for aviation medical certification, AJCC 8<sup>th</sup> edition stage specific certification assessment guidance chart was developed based on the updated prognostic data. This presentation will cover the aeromedical concerns of melanoma, CASA's approach to aeromedical decision making of melanoma and the risk assessment guidance chart.

#### Learning Objectives

1. The participant will learn about the principles of aeromedical risk assessment of melanoma.
2. The participant will learn about the estimated risk of incapacitation for each stage of melanoma and when does the risk drops below the acceptable level of certification for advanced melanoma.

### [111] PRESSURE URTICARIA IN A CAREER ENLISTED AVIATOR FOLLOWING A HIGH-ALTITUDE RAPID DECOMPRESSION

Christina Ingram, David Blum, Whitney Doiley Hawkins  
U.S. Air Force, Joint Base San Antonio-Lackland, TX, United States

#### (Education - Case Study)

**INTRODUCTION:** This case report described pressure urticaria presentation in a airborne mission systems operators following a high-altitude rapid decompression. **BACKGROUND:** The patient was a 35-year-old male with no previous history of pressure related disorders. He had an insignificant flying physical prior to technical school and no DNIFs outside of acute colds or soft tissue injuries. He had roughly 1,700 hours at the time of the event. The patient was a regular high-altitude research subject for 9 months prior to the event. He had participated in 9 rapid decompressions to altitudes up to FL300 prior to the event. **CASE PRESENTATION:** The patient participated in a rapid decompression to FL450 in preparation for a planned high-altitude research activity. The patient had no adverse presentations immediately post-exposure and returned home. The next day, the patient woke up and was notified by his spouse of "lumps" along his back. The patient contacted the research coordinator and was advised to go to BAMC for a suspected decompression sickness presentation. He was dove in the hyperbaric chamber for 1.5 hours and put on steroids for two weeks by the treating flight surgeon. After the course of steroids, the patient experienced a return and increase in severity of symptoms. The patient was prescribed three different types of antihistamines to be taken twice daily. The patient experienced relief from symptoms but severe degradation in quality of life. During this time, the patient was diagnosed with uncontrollable pressure urticaria. **DISCUSSION:** Under treatment by a flight surgeon, the patient was prescribed cyclosporine which was unsuccessful, but also started a waiver process prematurely. The patient was disqualified by the MAJCOM SGP and ultimately prescribed Xolair (300mg) to control his symptoms.

#### Learning Objectives

1. The audience will learn about development of pressure urticaria following a rapid decompression.
2. The audience will learn about treatment following pressure urticaria in a career enlisted aviator.

### [112] UK CAA'S UPDATED HIV POLICY AND REVIEW OF UK LICENSED PILOTS LIVING WITH HIV

Ewan Hutchison

UK Civil Aviation Authority, Crawley, United Kingdom

#### (Education - Program/Process Review)

**BACKGROUND:** The UK CAA initially published guidance for the assessment of pilots living with HIV in 2008. There have been significant advancements in the management of HIV since, with improved life expectancy and quality of life. From 2015, all people with newly diagnosed HIV infection in the UK are offered anti-retroviral therapy (ART). As a result, most applicants applying for certification now have short periods between seroconversion and commencing therapy, normal CD4 counts and undetectable viral loads. **OVERVIEW:** Fitness assessments for aeromedical certification are based on assessing functional ability and incapacitation risk associated with any medical conditions an applicant has declared. With HIV seropositivity, the risks arise from secondary infections/AIDS defining conditions and associated co-morbidities such as mental health conditions, cardiovascular disease and the adverse effects of medication. There are also concerns about the development of neurocognitive impairment (NCI) and a number of risk factors have been identified for this. The UK CAA has updated its policy for assessing applicants living with HIV with co-operation and expert input from the British HIV Association. It is possible for applicants with well controlled infection, no demonstrable NCI and/or low risk for developing NCI to obtain unrestricted Class 1 certification. Publishing our guidance improves the transparency of our assessments and helps applicants living with HIV to make decisions about training for a commercial pilot's licence. The UK CAA announced a period of reset, where certificate holders who had previously failed to declare their HIV seropositivity could do so without risk of enforcement action. The medical history of 28 Class 1 applicants/certificate holders living with HIV, including 18 currently flying, were reviewed against the new policy. **DISCUSSION:** The issuance of medical certificates to applicants living with HIV who wish to start training for a commercial pilot's licence remains controversial in some parts of the world, as does the need for regular formal neurocognitive testing. We believe that the UK policy provides a safe and pragmatic assessment of fitness and makes it more likely that pilots will declare their status so that they can have a proper and fair assessment of their fitness.

#### Learning Objectives

1. The audience will learn about the risk factors for incapacitation that arise from HIV infection.
2. The audience will learn about the UK CAA's updated policy for assessing fitness of applicants living with HIV.

Monday, 05/22/2023  
Napoleon Ballroom C1-C2

4:00 PM

### [S-21]: SLIDES: NEW ANGLES IN HUMAN SYSTEMS INTEGRATION

Chair: Jamie Harvey

Co-Chair: Connie Ramsburg

### [113] INFLUENCE OF SEAT BACK ANGLE AND FLIGHT JACKET WEAR ON WORK OF BREATHING

Ross D Pollock<sup>1</sup>, Mani Coonjobeeharu<sup>1</sup>, Ilya Bychkov<sup>1</sup>, Leann Maanum<sup>1</sup>, Aiden Coffey<sup>2</sup>, Camille Bilger<sup>2</sup>, Gerreard F. Rafferty<sup>1</sup>, Caroline J. Jolley<sup>1</sup>, Peter D. Hodkinson<sup>1</sup>, Thomas G. Smith<sup>1</sup>

<sup>1</sup>King's College London, London, United Kingdom; <sup>2</sup>Martin-Baker Aircraft Company, London, United Kingdom

*(Original Research)*

**INTRODUCTION:** Altering the seat back angle in a fast jet may be considered as a mean to improve G-tolerance or comfort, however, the altered gravitational vector could increase work of breathing (WoB). The additional mass of a flight jacket and the items stored within it could further increase this load. Given the suggested relationship of some unexplained physiological events with WoB and the potential for seat back angle to influence this the current study aimed to determine the effect of seat back angle and flight jacket mass on WoB. **METHODS:** Eight healthy participants (3 males, 5 female) were secured in an ejection seat reclined to 20°, 35° and 50° using a 5-point harness. Testing was performed with and without a flight jacket which had a 5kg mass distributed in 2 pockets over the lower thorax. A gastro-oesophageal pressure catheter was used to determine transdiaphragmatic pressure-time-product ( $PTP_{di}$ ) providing an index of WoB. Neural respiratory drive index (NRDI) was determined from surface electromyography of the parasternal intercostal muscles. Tidal volume ( $V_t$ ), respiratory rate (RR) and minute ventilation ( $V_e$ ) were recorded using a pneumotachograph. Each test condition lasted 3 mins with the participant breathing normally. All procedures were approved by a local ethics committee. **RESULTS:**  $PTP_{di}$  increased significantly (up to 60%) with more reclined seat back angles. Wearing a flight jacket increased  $PTP_{di}$  by 38% at a seat back angle of 50°. No effect was observed at 20° and 35°. Overall NRDI was significantly greater when wearing a flight jacket but was unaffected by seat back angle. Seat back angle and use of flight jacket had no effect on any other respiratory variables. **DISCUSSION:** Overall, WoB was increased with more reclined seat back angles, and further exacerbated at greater angles of recline (50°) when using a flight jacket. There was minimal effect of wearing a flight jacket on WoB in more upright postures. If ejection seats with greater angles of recline are to be used consideration should be given to lowering or redistributing the mass of the flight jacket (and associated equipment) to limit the impact on WoB.

**Learning Objectives**

1. Understand the influence of ejection seat back angle on work of breathing.
2. Describe the influence of flight jacket use in combination with changes in seat back angle on work of breathing.

### [114] BREATHING RHYTHM COMPLEXITY AS AN INDICATOR TO RESPIRATORY COMPROMISE FOR FUTURE FLIGHT DECK SYSTEMS

Nicholas Napoli<sup>1</sup>, Jeremy Prieto<sup>1</sup>, Rheagan Pratt<sup>1</sup>, Chad Stephens<sup>2</sup>, Kellie Kennedy<sup>2</sup>

<sup>1</sup>University of Florida, Gainesville, FL, United States; <sup>2</sup>NASA Langley Research Center, Hampton, VA, United States

*(Original Research)*

**INTRODUCTION:** Detecting the impact of respiratory loads and stressors on the respiration system is critical to understanding the dynamics within the respiratory system and the stresses imposed on the human within flight deck systems. Analysis of breathing rate, frequency, and period has been a commonly conflated terminology that is utilized in evaluating breathing. We propose a new approach to analyzing respiratory compromise using the induction of hypoxia, called Breathing Rhythm Complexity. **METHODS:** Professional pilots served as test subjects ( $n=57$ , 49 males) in a study involving simulated altitudes of sea level (21.0% O<sub>2</sub>) and 15,000 feet (11.2% O<sub>2</sub>) induced by an Environics, Inc. Reduced Oxygen Breathing Device (ROBD). Each subject experienced both non-hypoxic and hypoxic ( $SPO_2 \leq 95\%$ ) exposures while performing three 10-minute tasks (computerized neuropsychology tests, computerized multitasking battery, and fixed-based flight simulation). The quantitative approach leverages our understanding that the respiratory signal is not composed of a pure sinusoidal wave. The waveform is decomposed at its zero-crosses to calculate individual inspiratory and expiratory times. The difference between these times is calculated using sample entropy, producing Breathing Rhythm Complexity. **RESULTS:** Preliminary results

comparing the hypoxic and non-hypoxic cohorts demonstrated no significant changes in time of inspiration and time of expiration variance and complexity (sample entropy). However, when observing respiratory rhythm complexity, a comparison between the cohorts demonstrated significant changes in respiratory rhythm complexity (sample entropy), achieving  $p < 0.0214$ . **DISCUSSION:** The preliminary results indicate the induction of hypoxic events and their impact on breathing rate, frequency, period, and rhythm under respiratory stress. The implications of these results suggest that a subject's breathing rate, frequency, and period may not always distinguish respiratory stress, but the dynamic nature of the breathing rhythm can. This understanding of breathing rhythm complexity can provide beneficial information into the nature of how human physiological systems (e.g. respiration) compensate under respiratory stress.

**Learning Objectives**

1. [The audience will learn about...] the importance of breathing rhythm complexity and its impact on respiratory compromise.
2. [The audience will learn...] the importance of extrinsic loads and environmental factors, such as hypoxia, and their impact on the respiratory system.

### [115] ENDOTRACHEAL INTUBATION EFFICACY IN HELICOPTER CABIN VS. GROUND: A SYSTEMATIC REVIEW AND A META-ANALYSIS

Lydia Johnson Kolaparambil Varghese<sup>1,2</sup>, Jochen Hinkelbein<sup>3</sup>, Edoardo De Robertis<sup>4</sup>, Jan Schmitz<sup>3</sup>

<sup>1</sup>Università degli Studi di Perugia, Terni, Italy; <sup>2</sup>European Society of Aerospace Medicine Space Medicine Group, Cologne, Germany; <sup>3</sup>University Hospital Cologne, Cologne, Germany; <sup>4</sup>Università degli Studi di Perugia, Perugia, Italy

*(Original Research)*

**BACKGROUND:** Pre-hospital endotracheal intubation (ETI) is a sophisticated procedure with a comparatively high failure rate. Especially, ETI in confined spaces may result in higher difficulty, longer times, and a higher failure rate. The aim of the present study was to analyze if HEMS intubation success and time are influenced by noise, light, restricted space in comparison to the ground intubation. The availability of literature reporting these parameters was very limited, thus we analyzed the reported differences between ETI in helicopter vs. ground by confronting parameters such as time to secure airway, first attempt success rate, visual Analog Scale (VAS) and Cormack-Lehane Score. **METHODS:** PUBMED, Cochrane Library and Ovid were consulted to perform a systematic review and meta-analysis in October 2022. Randomized control trials (RCTs) comparing ETI in helicopter to ground were included in the meta-analysis. The study was registered at the International Prospective Register of Systematic Reviews (PROSPERO) with number CRD42022361793. The database search provided 1049 studies, of which 3 studies met inclusion and quality criteria for the meta-analysis. **RESULTS:** The mean duration of intubation on helicopter was around 17,65 seconds vs. the 18,83s on ground. The median time to secure airway  $\pm$  SD on helicopter was  $217,00 \text{ s} \pm 16,00$  vs  $184,50 \text{ s} \pm 46,50$  on ground. The mean  $\pm$  SD of the Visual Analogue Scale (VAS) on helicopter was  $2,00 \pm 1,00$  vs  $2,40 \pm 0,40$  on ground. Cormack-Lehane Score saw instead a mean  $\pm$  SD of  $1,33 \pm 0,33$  on helicopter compared to  $1,26 \pm 0,26$  on ground. The difference of intubation success between each seems not to be significant. **CONCLUSION:** Further research is needed to assess the impact of environmental factors on the quality of ETI on HEMS.

**Learning Objectives**

1. The audience will learn about the differences in the airway management between a helicopter cabin and ground.
2. The participant will be able to learn the factors impacting the ETI in both environments, and the efficacy of each.

### [116] DERIVING HELMET SYSTEM MASS PROPERTY REQUIREMENTS THAT MITIGATE AIRCREW NECK PAIN

Philip Farrell

DRDC, Toronto, ONT, Canada

*(Original Research)*

**INTRODUCTION:** Aircrew helmet systems have been designed primarily for blunt and crash protection. Over time, the helmet itself has become a key platform for communication, breathing, and enhanced vision systems, thus altering its mass properties with unintended consequences of unacceptably high aircrew neck pain prevalence rates. Recognizing that this debilitating pain negatively impacts mission success and aircrew careers, the Royal Canadian Air Force (RCAF) Hornet Extension Programme required that any newly acquired helmet system must reduce the risk of developing or aggravating aircrew neck pain.

**METHODS:** A linear relationship is initially proposed between neck pain prevalence rates and mass properties for deriving helmet system mass property requirements. Known mass property values and prevalence rates were used from current in-service helmet systems – i.e., Joint Helmet Mounted Cueing System has higher inertia and prevalence rate (74%) than the 190A with Night Vision Goggles (NVGs) that has lower inertia and prevalence rate (68%) – to define the slope of the line. The mandatory new helmet system inertia criteria was set at the inertia value of the 190A with NVGs. The point-rated criteria was based on the slope of the line: that is, the lower the proposed helmet system inertia, the more points were awarded to the proposal. **RESULTS:** This derivation yields two key observations. First, as the helmet system inertia moves down the positively sloped line, the prevalence rate also decreases proportionally, but at some point a helmet system with very low inertia, which also provides protection and a platform, becomes technologically infeasible. Second, the prevalence rate and mass property relationship is unlikely linear but more likely curvilinear (an S-shape). More than two points are needed to determine this relationship. Unfortunately, air forces may have only two points, namely, day- and night-configured helmet systems and associated prevalence rates. **DISCUSSION:** Despite these limitations, the RCAF successfully employed these requirements to assess industry proposals and make acquisition decisions for the fast air community. This represents a shift towards neck pain mitigation as a primary helmet system requirement. Perhaps several nations can pool their prevalence rate and mass property data points to better estimate this relationship.

**Learning Objectives**

1. Understand a shift in defining helmet system requirements based primarily on mitigating neck pain, secondly on a key platform for communication, breathing, and enhanced vision systems, and lastly on blunt and crash protection.
2. Understand that a linear relationship is not likely the true relationship and will yield a situation where the curve will reach a point where it is technologically infeasible to build a helmet system with very low inertia.
3. Understanding that finding a relationship between prevalence rates and helmet system mass properties is an empirical endeavor, and there may not be enough data points to adequately find this relationship.

### [117] PREVALENCE OF BACK PAIN AND PREVENTIVE MEASURES IN THE SWISS AIR FORCE - EVALUATION OF THE LAST 10 YEARS

Denis Bron, Janine Rochelt, Nadja Saba, Sven Rochelt  
*Fliegerärztliches Institut, Dübendorf, Switzerland*

*(Original Research)*

**INTRODUCTION:** The normal function of back and neck muscles is essential for Swiss Air Force pilots. In case of an imbalance, back pain may be a consequence. The results of a first examination in 2012 in the status of a student pilot were implemented to perform a regular preventive training. To review the measures taken, the data collected over the last 10 years on trunk strength testing and subjective back pain were evaluated. Furthermore, correlation analysis on aircraft, trunk stability and back pain has been done. **METHODS:** 454 male Swiss Airforce pilots participated in an annual standardized trunk strength test over the last 10 years. Additionally, they provided information about subjective back pain. To

analyze the correlation between subjective and objective parameters, a linear regression was performed. **RESULTS:** 63.4% of all Swiss Airforce pilots suffer from back pain at least once in their lives. Of these, 44.1% have acute pain and 55.9% have chronic pain. 36.1% report feeling their pain in the lumbar spine, 20.8% in the cervical spine and 6.6% in the thoracic spine. 36.5% complain of pain in multiple locations in the back. No significant correlation was found between occupation and pain ( $p=0.39$ ), as well as aircraft type and pain ( $p=0.15$ ). There is a significant negative correlation between dorsal performance on the trunk strength test and subjective back pain ( $p\leq 0.05$ ) as well as between age and performance achieved ( $p\leq 0.01$ ). **DISCUSSION:** Almost two-thirds of pilots suffer from back pain at least once in their life. This high prevalence may be due to the occupationally related higher loads on the musculoskeletal system. Higher performance of the dorsal muscle chain has a positive effect on back health. The performance of the lateral and ventral muscle groups shows no significant correlation. The younger the pilots, the higher their performance on the trunk strength test. The regular coaching of the young pilot classes and the associated awareness of prevention may provide an explanation for this. Based on these findings, preventive training focusing on the dorsal muscle chains for student pilots will be continued and extended. In addition to this, even more specific mentoring of the existing flying professional personnel of the Swiss Air Force will be pursued.

**Learning Objectives**

1. Understand the correlation between performance on the trunk strength test and subjective back pain.
2. Learn about the measures taken to prevent back pain within the Swiss Airforce.

### [118] LOGIC ANALYSIS OF PHYSIOLOGICAL AND SYSTEM MONITORING FOR HIGH PERFORMANCE JET AIRCRAFT

Aiden Coffey<sup>1,2</sup>, Peter Hodgkinson<sup>1</sup>, Ross Pollock<sup>1</sup>, Pete Marston<sup>2</sup>  
<sup>1</sup>Kings College London, London, United Kingdom; <sup>2</sup>Martin-Baker Aircraft Company Ltd., London, United Kingdom

*(Education - Program/Process Review)*

**BACKGROUND:** Military aviation exposes aircrew to stressors that, without effective protection and mitigation, may degrade their ability to operate the aircraft and endanger their lives. Over the past 20 years there has been a rise in Unexplained Physiological Events (UPEs). However, in the absence of pilot physiological data, or often life support system data, investigators may be left to make inferences about UPE causation based on limited data, including how aircrew are affected by the event. UPEs have, therefore, renewed interest in pilot physiological monitoring, although targets for monitoring have yet to be widely agreed upon. Attempts at monitoring often lack adequate consideration of what is feasible to monitor, whether meaningful, accurate and reliable data can be obtained throughout the flight envelope, and how to use the gathered data. **OVERVIEW:** This presentation will challenge the role of physiological monitoring and advocate that, in many settings, systems monitoring is a more appropriate solution. This is based on a logic analysis to assess both system and physiological monitoring options, with the intent being to identify the best solution for the risk being addressed and associated operational use case. There will also be a proposal of a novel process and set of governing principles for the selection, test, and development of physiological and system monitoring. Operational use-cases will be discussed ranging from detection of physiological phenomena for a variety of in-flight uses through to post-flight analysis for e.g. training, incident or accident investigation. The different confidence levels in the system or physiological data required for each use-case will be compared. **DISCUSSION:** The implementation of monitoring systems will require adherence to an evidence-based development process. This process will require a set of principles to operate within, at the forefront of which is a critical logic-based analysis of what variable(s), be it system or physiological monitoring, is most appropriate. Where physiological monitoring is the best solution, it is vital that the measuring system be appropriately validated to have confidence in data gathered in the challenging environment of high-performance jet aircraft. Successful implementation of

these systems may improve safety of flight through access to previously unavailable in-flight physiological or system data. This work is of interest to both military and civilian aerospace professionals.

#### Learning Objectives

1. The attendee will understand how the military aviation environment complicates monitoring of human physiology.
2. The attendee will understand the different use-cases for physiological monitoring and why, in some cases, system monitoring is more appropriate.
3. The attendee will understand the different use-cases for physiological data collected in-flight.

**Monday, 05/22/2023**

**4:00 PM**

**Napoleon Ballroom D1-D2**

## [S-22]: PANEL: OPERATIONAL VISION II: VISUAL PERFORMANCE AND PROTECTION

**Chair: Micah Kinney**

**Co-Chair: Adam Preston**

**PANEL OVERVIEW:** This panel will be part two in a two panel series on operational vision topics. Part two will review current research from the U.S. Air Force Operational Vision Assessment Lab (OBVA), Naval Medical Research Unit Dayton (NAMRU-D), and Australian Defense Science and Technology Group (DSTG) on topics related to visual performance and protection. First, OBVA will present results from a test-retest study of a novel vision screening apparatus, the Automated Vision Tester (AVT; Hedgefog Research Inc., San Pedro, CA). Results on the ability of the AVT to predict operational performance will be presented. Second, data will be presented from OBVA involving a multivariate analysis of AVT vision metrics from a large sample of USAF participants and how this may impact aviation selection. The third presentation will discuss NAMRU-D's research on gaze patterns and information-processing abilities of aviators in a flight simulator. These eye tracking metrics could be applied to gauge when visual performance enhancement plateaus in a training environment or to assess mental workload and task difficulty with eye tracking. Fourth, a presentation by DSTG on progressive multifocal lenses and their impact on aviator visual performance. Finally, a presentation from DSTG will discuss how laser eye protection impacts color vision performance among normal and color deficient aircrew. The implications from these findings stress the importance of balancing vision protection with visual performance.

### [119] VISION SCREENING PARAMETERS PREDICT OPERATIONAL PERFORMANCE IN A REMOTE 3D TASK

Jonelle Knapp, Margaret Hollander, Eleanor O'Keefe, Marc Winterbottom, Eric Seemiller

U.S. Air Force Research Lab, Dayton, OH, United States

#### (Original Research)

**INTRODUCTION:** Current United States Air Force (USAF) vision screening methods are based on WWII-era tests and are poor predictors of an Airman's ability to succeed in today's complex environments. Here, we investigate the test-retest reliability of a novel vision screening apparatus, the Automated Vision Tester (AVT; Hedgefog Research Inc., San Pedro, CA) and its ability to assess relationships between vision and performance. **METHODS:** Test-retest reliability data were collected from 43 participants (mean age  $36 \pm 8$  years) using the AVT. Threshold-level metrics for AVT vision tests (visual acuity, achromatic contrast sensitivity (ACS), cone contrast sensitivity (CCS), stereo acuity, and vertical and horizontal phoria) were collected at near (16 inches) and far (20 feet) for each subject on two different days. Bland-Altman analyses were used to evaluate test-retest reliability for each AVT test; vision tests were considered reliable if its internal variance (95% limits of agreement) was less than its external variance (1.96 standard deviations). Next, we investigated the

operational usefulness of AVT metrics to predict performance for a stereo 3D remote vision system (S3D RVS) virtual task. In the task, 13 participants were required to accurately align a mechanical gripper to drop a ball into a cup, placed at random positions horizontally and in depth as many times as possible within a 30-minute session. **RESULTS:** Most AVT tests (visual acuity, ACS, CCS, stereo acuity, and phoria) had good test-retest reliability. Two AVT tests had borderline acceptable test-retest reliability: low spatial frequency ACS at near (bias = 0.00; 95% limits of agreement = -0.12 to +0.10) and high spatial frequency ACS at far (bias = +0.02; limits of agreement = -0.20 to +0.24). Five AVT vision tests correlated with task performance: visual acuity ( $r=0.78$ ); ACS low spatial frequency ( $r=0.43$ ); ACS high spatial frequency ( $r=0.42$ ); far horizontal phoria ( $r=0.47$ ); and near vertical phoria ( $r=-0.52$ ). **DISCUSSION:** The Automated Vision Tester provides reliable measures of visual acuity, CCS, stereo acuity, and phoria, though users should exercise caution when using ACS measures. The AVT's threshold-level vision metrics may be useful to investigate relationships between vision and performance; however, more data is needed to confirm the reliability and usefulness of AVT vision metrics given our small study sample.

#### Learning Objectives

1. Understand the utility of Automated Vision Tester (AVT) vision metrics for aeromedical applications, such as a remote vision system 3D virtual task.
2. Understand what characteristics vision tests/vision metrics need to be of use to investigate relationships between visual function and operational performance (e.g., good test-retest reliability, minimal ceiling floor effects, good granularity).

### [120] MULTIVARIATE APPROACHES TO VISION SCREENING

Eric Seemiller<sup>1</sup>, Jonelle Knapp<sup>1</sup>, Eleanor O'Keefe<sup>2</sup>, Marc Winterbottom<sup>1</sup>, Steven Hadley<sup>1</sup>

<sup>1</sup>U.S. Air Force, Wright-Patterson AFB, OH, United States; <sup>2</sup>KBR, Inc, Beaver-creek, OH, United States

#### (Original Research)

**INTRODUCTION:** Due to time constraints and test limitations, only a select number of vision tests can be administered to measure ocular health and assess medical fitness for duty. Personnel can be disqualified by failing a single test, even though they may score well above normal on the other tests. And, of course, there's considerably more to visual processing than one's ability to read a 20/20 letter on a chart. Thus, it may be more beneficial to consider the observer's visual system as a whole unit, rather than assessing fitness for duty using individual pass/fail criteria. It is increasingly feasible through big data methods to compile multivariate characterizations of the entire visual system, creating more powerful and predictive screening metrics. Here, we present two such methods and demonstrate their aeromedical screening utility. **METHODS:** The Automated Vision Tester (AVT) provides threshold level estimates of visual processing across 14 vision tests: achromatic contrast sensitivity at 3 optotype sizes, acuity, cone contrast sensitivity for 3 cones, 2 tests of motion coherence, and 5 tests of binocular function. 192 participants (including 22 USAF aerial refueling boom operators) provided data for each test. Estimated threshold values were used for multivariate analyses. **RESULTS:** A factor analysis revealed 5 latent factors in the dataset that explained 82% of the variance. They were related to 1) high spatial frequency vision, 2) binocular function, 3) color vision, 4) motion processing and 5) low spatial frequency vision. Comparing boom operators to the general public, factors 1 ( $d' = 1.611$ ) and 2 ( $d' = 0.930$ ) discriminated group membership better than their constituent variables. A second approach, discriminate function analysis, created a full dataset factor ( $d' = 1.262$ ) that outperformed all individual variables for discriminating group membership. **DISCUSSION:** We present two multivariate approaches that treat simple vision screening metrics as parts of a more powerful whole. Both approaches created factors that discriminated the visual profile of an occupation better than single variables alone. This approach, combined with precise, threshold level vision tests, provides a method to identify redundancy and thus reduce the time required for aeromedical

vision screening. Additionally, treating the visual system as a whole, using multivariate factors, may predict operational performance better than single vision metrics alone.

#### Learning Objectives

1. The audience will learn to use and interpret big data methods for analyzing vision screening metrics.
2. The audience will learn to consider the visual system as a system rather than a series of individual measurements.

### [121] QUANTIFYING AVIATOR VISUAL SCAN PATTERNS AND INFORMATION PROCESSING PROFICIENCY IN A SIMULATED FIXED WING AIRCRAFT

Roy Hoffman, Lucas Haberkamp, Charles Weisenbach, Michael Reddix  
U.S. Navy, Dayton, OH, United States

#### (Original Research)

**INTRODUCTION:** Aviators develop a more structured visual scan pattern and increased efficiency in extracting cockpit instrument information as they gain experience. Visual performance may be quantifiable by measuring eye movement and then calculating sample entropy and fixation duration. Sample entropy evaluates the visual scan pattern by measuring the degree of disorder or randomness over time, while fixation duration measures the information processing proficiency. Our study aimed to evaluate the validity of using these metrics to assess the aviator's visual performance. We hypothesized that while landing compared to other phases of flight, a more predictable gaze pattern (lower sample entropy) and higher fixation duration would occur. **METHODS:** Using a collimated-display flight simulator configured as a T-6A Texan II USN/USMC/USAF turbo-prop training aircraft, fourteen aviators with current or previous turbo-prop flying experience were directed to perform a five-phase flight. The phases consisted of 1) takeoff 2) new heading and altitude change 3) constant rate turn 4) new heading and altitude change 5) landing. Eye tracking data were collected with Smart Eye Pro (Smart Eye, Inc., Gothenburg, Sweden). Sample entropy and mean fixation duration were calculated for each phase. A repeated measures ANOVA and pairwise *t* post-hoc tests were used to evaluate differences between phases of flight. **RESULTS:** Sample entropy and mean fixation duration showed significant differences ( $p < 0.001$ ) between phases of flight. Pairwise *t* post-hoc tests found significant differences between landing and all other phases of flight. No independent significant differences were found between phases of flight 1-4, except for sample entropy between phases 2 and 4. **DISCUSSION:** Aviators appeared to have more predictable scan patterns and higher fixation durations during landing compared to other phases which supported our hypothesis. These results reflect the increased task difficulty and mental workload during landing. Sample entropy and fixation duration may be useful metrics to quantify the gaze patterns and information-processing abilities of aviators. These metrics could be applied to gauge when visual performance enhancement plateaus in a training environment or to assess mental workload and task difficulty with eye tracking.

#### Learning Objectives

1. Understand how visual performance, by measuring eye movement, is related to entropy and fixation duration.
2. Understand the differences and predictability during phases of flight of aviators' scan patterns and fixation durations in the cockpit and outside of the cockpit.

### [122] METHODOLOGY TO EVALUATE OPTICAL LENS DESIGNS FOR MILITARY ROTARY WING PLATFORMS

Amanda Douglass<sup>1</sup>, Renee Karas<sup>2</sup>, Kate Coffey<sup>1</sup>, Larry Abel<sup>1</sup>, John Parkes<sup>3</sup>, Maria Gavrilescu<sup>2</sup>

<sup>1</sup>Deakin University, Geelong, Australia; <sup>2</sup>Defence Science and Technology Group, Melbourne, Australia; <sup>3</sup>University of Melbourne, Melbourne, Australia

#### Original Research

**INTRODUCTION:** Progressive multifocal lenses (PML) were prohibited for military aircrew when they first became available due to large peripheral aberrations, with operators restricted to bifocal lenses. Lens designs have improved significantly, with less aberrations therefore some services have recently allowed PMLs. Some concern has persisted for rotary wing (RW) aircrew, therefore a method to evaluate operationally relevant differences was developed. **METHOD:** In-depth interviews were conducted with instructor pilots to identify critical day and night vision tasks (including interaction with night vision devices and symbology) and current issues with optical correction within the cockpit in 3 rotary wing platforms. The size of critical elements in each task were recorded. Free-form PMLs and bifocals were made based on the optical prescription required for the distances identified. In lab and ground cockpit psychometric vision testing was developed to evaluate the different lens designs. **RESULTS:** The majority of cockpit tasks identified require intermediate distances correction (60-80cm). In some operational roles near vision overhead (25-50cm) is required. NVDs significantly narrow the field of view (FOV) to 40 degrees and require the exit pupil of the NVD and the far vision portion of the lens design to align precisely. Bifocal and trifocal lenses not set precisely were reported to create sharp demarcations of blurred symbology. Critical elements were 9.6 arc min or larger. In lab mesopic contrast sensitivity was evaluated on axis, 17 degrees off axis horizontally, and with a chin tilt to align each participant in the addition segment of the bifocals. For ground trials, a dynamic visual acuity task undertaken at different contrast levels was developed for a small screen placed in the cockpit. Distance visual acuity was measured with symbology and cockpit lighting on to provide an accurate lighting environment. No clinically significant differences were seen between PMLs and bifocal lenses in any of the near visual assessments. PMLs display improved results relative to the bifocals for the tilt test. All thresholds measured for both PMLs and bifocals were significantly better than that required for the critical elements. **CONCLUSION:** A method for evaluating optical correction designs has been identified and may be used to evaluate future designs.

#### Learning Objectives

1. The participant will understand the complexity of the human, optical system interface in different rotary wing systems.
2. The participant will develop an understanding of how to evaluate different optical lenses for rotary wing pilots.

### [123] MODERNISING COLOUR VISION TESTING FOR INCLUSION WHILST MAINTAINING SAFETY WHEN LASER EYE PROTECTION IS REQUIRED

Maria Gavrilescu<sup>1</sup>, Kate Coffey<sup>2</sup>, Renee Karas<sup>1</sup>, Larry Abel<sup>2</sup>, Amanda Douglass<sup>2</sup>

<sup>1</sup>Defence Science and Technology Group, Melbourne, Australia; <sup>2</sup>Deakin University, Geelong, Australia

#### (Original Research)

**INTRODUCTION:** Current standards for aviation color vision were established in WW2 when the color vision requirements were very different. These standards have been challenged in civil aviation. Modern color vision testing should take into account specific task requirements and make use of technology to individualize tasks where possible. An application of increasing relevance in the current geopolitical context is the use of laser eye protection (LEP) in military aviation while also processing complex visual information that is presented in color from on-board instrumentation. **METHODS:** The effect of wearing LEP on color vision normal (CVN) and color vision deficient (CVD) individuals was examined using the Konan CCT-HD, CAD, and FM100. Participants' task performance on a driving simulation with standard colors versus tailored colors to compensate for LEP effects was compared. The driving task included a primary task following a colored map in a head down display (HDD) and obeying road rules. Participants were also asked to respond to HAFU colored symbols

that were overlayed on the driving scene. Participants were required to correctly identify the color of the HAFU symbols. **RESULTS:** Ten CVN and five CVD participants were recruited and their color perception was examined across a range of LEPs. The use of LEPs resulted in a significant change in color perception which were highly LEP specific. For CVNs the average change from baseline in CCT-HD scores were L-75 M-50 S-54.3 for LEP1, L-52.8 M-35.4 S-9.7 for LEP2, L+7.4 M+7.6 S-34.8 for LEP3 and L-22.7 M-32.4 S-62.7 for LEP 4. CVD observers showed mixed results for CCT-HD. Changes in L, M, S scores for CVD were specific to the type of color vision deficiency and were LEP specific. Task performance significantly improved with customized colors. The CAD and CCT-HD were more sensitive to changes than the FM100. **DISCUSSION:** Color requirements should use modern color assessment techniques to determine if support to create an inclusive workforce is possible. Customized color displays can be used to compensate for color filters used in vision protection devices such as LEPs. Future research will examine whether customized color palettes can potentially be used to improve performance for CVD individuals.

#### Learning Objectives

1. The participant will develop an understanding of which color vision tests are appropriate for evaluating color perception in an aviation context.
2. The participant will develop an understanding of how laser eye protection affects color perception.

**Monday, 05/22/2023**  
**Napoleon C3**

**4:00 PM**

### [S-23]: PANEL: CARDIOVASCULAR, HEMATOLOGY, AND ENDOCRINE CONSIDERATIONS FOR COMMERCIAL SPACEFLIGHT AND ANALOG ENVIRONMENTS

**Chair: Rebecca Blue**

**Co-Chair: Karen Ong**

**PANEL OVERVIEW:** The coming of the commercial age of spaceflight portends a paradigm shift concerning the medical qualifications of future spaceflight participants. Conditions such as diabetes mellitus and cardiovascular disease may be prevalent in the population of potential future spaceflight participants and may present additional risk factors in the hypergravity environment, from acceleration tolerance to the ability to carry out moderately complex tasks in emergency or high-stress operational scenarios. While certain disease-related sequelae are likely to represent criteria for exclusion from near-future spaceflight activity, the inclusion of individuals with well-controlled disease without significant sequelae is desirable in the commercial spaceflight industry. To address some of these issues, a study was conducted under funding from the FAA Center of Excellence for Commercial Space Transportation in which layperson volunteers were exposed to high-fidelity centrifuge-simulated suborbital spaceflight. This panel will discuss approaches to risk stratification of various cardiovascular, hematological, and endocrine conditions as they relate to inclusion of individuals with such conditions in commercial spaceflight activities.

#### [124] CARDIOVASCULAR, HEMATOLOGY, AND ENDOCRINE CONSIDERATIONS FOR COMMERCIAL SPACEFLIGHT AND ANALOG ENVIRONMENTS

Ronak Shah, William Powers, Serena Auñon-Chancellor, Rebecca Blue

UTMB, Galveston, TX, United States

(Original Research)

The coming of the commercial age of spaceflight portends a paradigm shift concerning the medical qualifications of future spaceflight participants. Conditions such as diabetes mellitus and cardiovascular disease may be prevalent in the population of potential future spaceflight

participants and may present additional risk factors in the hypergravity environment, from acceleration tolerance to the ability to carry out moderately complex tasks in emergency or high-stress operational scenarios. While certain disease-related sequelae are likely to represent criteria for exclusion from near-future spaceflight activity, the inclusion of individuals with well-controlled disease without significant sequelae is desirable in the commercial spaceflight industry. To address some of these issues, a study was conducted under funding from the FAA Center of Excellence for Commercial Space Transportation in which layperson volunteers were exposed to high-fidelity centrifuge-simulated suborbital spaceflight. This panel will discuss approaches to risk stratification of various cardiovascular, hematological, and endocrine conditions as they relate to inclusion of individuals with such conditions in commercial spaceflight activities.

#### Learning Objectives

1. This panel will discuss the tolerance of individuals with significant medical history, including recent cardiac surgery and hemophilia, experiencing hypergravity.
2. This panel will discuss the development of a mathematical model for prediction of hypergravity tolerance in laypersons.

#### [125] A DYNAMIC MATHEMATICAL MODEL FOR THE PREDICTION OF CARDIOVASCULAR RESPONSE TO HYPERGRAVITY

Karen Ong<sup>1</sup>, Alanna Kennard<sup>2</sup>, Zan Ahmad<sup>3</sup>, Charles Peskin<sup>4</sup>, Rebecca Blue<sup>1</sup>

<sup>1</sup>UTMB, Galveston, TX, United States; <sup>2</sup>New York University, New York, NY, United States; <sup>3</sup>Johns Hopkins Whiting School of Engineering, Baltimore, MD, United States; <sup>4</sup>New York University Courant Institute of Mathematical Sciences, New York, NY, United States

(Original Research)

**INTRODUCTION:** Expansion of the commercial spaceflight industry will allow individuals with a variety of pre-existing medical conditions and limited aerospace experience and training to engage in spaceflight and analog activities. As cardiovascular conditioning is directly associated with hypergravity tolerance, the ability to predict cardiovascular response to hypergravity conditions could allow for improved risk profiling. Previously, we created a minimal steady-state mathematical model using anthropometric measurements to individualize +Gz-tolerance prediction. While a useful preliminary effort, steady-state modeling cannot truly predict real-world performance, as G-tolerance depends not only on the maximum G force experienced but also the rate of onset and the hypergravity context. We present a dynamic model of the cardiovascular system under hypergravity designed to use individualized parameters and variable G-profile data for improved predictive outcomes. **METHODS:** This ordinary differential equation model is comprised of a thoracic compartment and upper and lower body compartments, with compartment heights determined by subject-specific measurements (eye-heart and heart-seat distances). The model treats the heart as a continuous flow device, with a time-dependent flow representing cardiac output. Notable features of the model include an idealized controller that maintains pressure in the upper compartment by changing heart rate and venous reserve volume. Additionally, we model partial venous collapse in the systemic veins entering the thoracic compartment. **RESULTS:** Simulations and model accuracy will be discussed in the context of human space-flight and available analog test data from human centrifuge exposure, including time-dependent physiological data such as cardiac output and heart rate. **DISCUSSION:** A dynamic model allows for inclusion of anthropometric inputs as well as acceleration profile parameters, including G-onset rate and variation of acceleration exposures over time. Accurate prediction of individual G-tolerance may allow for stratification of risk for individuals with varied medical history. Further uses include the prediction of which spaceflight participants may require use of anti-G straining maneuvers for prevention of symptoms related to hypergravity exposures exceeding cardiovascular tolerance. Implications for medical risk stratification and decision-making will be discussed in the context of human spaceflight.

### Learning Objectives

1. To understand the advantages and disadvantages of steady state versus dynamic mathematical models.
2. To understand a dynamic mathematical model of cardiovascular circulation under hypergravity.
3. To understand how this dynamic mathematical model compares with existing human centrifuge data.

### [126] TOLERANCE OF CENTRIFUGE-SIMULATED COMMERCIAL SPACEFLIGHT IN A SUBJECT WITH HEMOPHILIA A

Isaiah Reeves<sup>1</sup>, Rebecca Blue<sup>1</sup>, Serena Auñón-Chancellor<sup>1</sup>, Ronak Shah<sup>1</sup>, William Powers<sup>1</sup>, Michael Harrison<sup>2</sup>

<sup>1</sup>UTMB, Galveston, TX, United States; <sup>2</sup>Axiom Space, Inc, Houston, TX, United States

#### (Original Research)

**INTRODUCTION:** With increasing engagement of commercial spaceflight participants in spaceflight activities, of particular concern is the evaluation of individuals with medical conditions not previously characterized in the spaceflight environment. In addition to physiologic changes of spaceflight, factors such as acceleration forces experienced during launch, reentry, and landing of spacecraft could pose an altered risk profile in those with known disease. Bleeding diatheses present a unique concern in the spaceflight environment given hypergravity exposure and, in particular, the injury potential from transient or impact acceleration. **METHODS:** A 26-year-old Caucasian man with severe hemophilia A and no detectable endogenous Factor VIII (FVIII) volunteered for participation in hypergravity exposures simulating suborbital spaceflight. At the time of the study, his treatment regimen included 50 IU/kg FVIII-Fc fusion protein intravenous administration every 96 hours, with supplemental FVIII administration as needed for any injury or bleeding episodes. The subject participated in 2 centrifuge profiles at the National Aerospace Training and Research Center (NASTAR) human centrifuge approximating suborbital and orbital spaceflight, with maximum exposure +4.0G<sub>z</sub>, +4.5G<sub>x</sub>, 6.1G resultant, and maximum onset rate <0.5G<sub>z</sub>/sec and +1G<sub>x</sub>/sec. His baseline medical regimen was unchanged for centrifuge exposure. **RESULTS:** The subject reported no abnormal events during the simulated flights other than brief, mild vertigo and transient disorientation, which resolved prior to profile completion. No petechial hemorrhage, ecchymosis, joint discomfort, effusion, or other bleeding was noted during or after acceleration exposures. Supplemental FVIII was not required at any time. **DISCUSSION:** From the perspective of commercial spaceflight, inherited bleeding disorders present several potential concerns that must be evaluated prior to participation. We discuss this subject's tolerance of simulated spaceflight, risk profile analysis, and generalizability of this case report to other hematological considerations and disorders. Cautious review and management of medical history, adherence to and barriers to treatment, duration of spaceflight and longitudinal management concerns, and a thorough and detailed risk/benefit assessment may provide a future pathway for inclusion of individuals with hematological disorders in commercial spaceflight.

### Learning Objectives

1. The audience will learn about centrifugation of an individual with a medical condition as an analog to spaceflight.
2. The audience will learn about aeromedical considerations of inherited bleeding disorders in commercial spaceflight.

### [127] CENTRIFUGE-SIMULATED ORBITAL AND SUBORBITAL SPACEFLIGHT IN A SUBJECT WITH RECENT MEDIAN STERNOTOMY FOR AORTIC VALVE REPLACEMENT

William Fernandez<sup>1</sup>, Rebecca Blue<sup>1</sup>, Michael Harrison<sup>2</sup>, Karen Ong<sup>1</sup>, Ronak Shah<sup>1</sup>, Serena Auñón-Chancellor<sup>1</sup>, William Powers<sup>1</sup>

<sup>1</sup>UTMB, Galveston, TX, United States; <sup>2</sup>Axiom Space, Inc, Houston, TX, United States

#### (Original Research)

**INTRODUCTION:** Human access to space is growing rapidly in the commercial environment, with private companies offering a variety of

orbital and suborbital spaceflight experiences to spaceflight participants (SFPs). SFPs are far more likely than career astronauts to have medical conditions novel to spaceflight and may not have undergone as rigorous a medical screening process as that used for career astronauts. This case report details the experience and physiological responses of a subject with recent median sternotomy for aortic valve replacement and atrial septal defect (ASD) closure to centrifuge acceleration simulating orbital and suborbital commercial spaceflight. **METHODS:** A 40-year-old male with a history of congenital bicuspid aortic valve and atrial septal defect with successful repair six months prior to centrifuge participated in ongoing human centrifuge research at the National Aerospace Training and Research Center (NASTAR). The subject had the opportunity to participate in up to five centrifuge runs in an 8-hour period, with profiles simulating commercial spaceflight. Maximum exposures included +4.0G<sub>z</sub>, +4.5G<sub>x</sub>, 6.1G resultant, and maximum onset rate <0.5G<sub>z</sub>/sec and +1G<sub>x</sub>/sec. Physiologic data acquisition included hemodynamics, electrocardiogram, neurovestibular exams, and post-run questionnaires covering motion sickness, disorientation, and similar symptoms. **RESULTS:** The participant tolerated the physiological aspects of centrifuge exposure well, though he noted progressive sternal pain with increasing G<sub>z</sub>, leading him to opt out of the final profile. Post-spin electrocardiograms demonstrated no changes from prior tracings and point tenderness of the sternum suggested a musculoskeletal origin of discomfort. Hemodynamic parameters remained normal for an age-matched cohort. He reported no adverse events before, during, or after any profile exposure. He pursued follow-up evaluation and imaging with his cardiologist after the experience, with no adverse outcomes.

**DISCUSSION:** We will discuss cardiac and operative considerations related to layperson hypergravity exposure. Post-cardiothoracic-surgery risks to SFPs are largely unknown, especially within twelve months of a surgical procedure, with limited to no data available for review. This case provides an approach for risk stratification, pre-participation evaluation, and medical management of a post-surgical patient with significant cardiac history in spaceflight and analog environments.

### Learning Objectives

1. The audience will learn a potential strategy for risk stratifying, evaluating, and medically managing a post-surgical patient with cardiac history for spaceflight and analog environments.
2. The audience will learn the effects of centrifuge-simulated orbital and suborbital spaceflight on a post-surgical cardiac patient.

### [128] HANDHELD SONOGRAPHIC CARDIOVASCULAR IMAGING UNDER HYPERGRAVITY CONDITIONS

Rebecca Blue, Karen Ong, William Powers

UTMB, Galveston, TX, United States

#### (Original Research)

**INTRODUCTION:** Tolerance of hypergravity depends on a number of factors including cardiovascular performance, though real-time cardiovascular imaging during hypergravity exposure has been historically limited by technological and physical challenges. Previous efforts at sonographic hypergravity imaging have used fixed probes; the use of hand-held technique particularly when performed by minimally-trained laypersons has been less explored. Here we discuss handheld sonography of carotid vascular and cardiac windows during hypergravity. **METHODS:** Three subjects with variable ultrasound experience (attending-level with extensive experience, resident-level minimal training, and no sonographic experience) used handheld ultrasound at rest and under stepwise +G<sub>z</sub> hypergravity exposures (maximum +3.8G<sub>z</sub>) to visualize carotid vasculature. Subjects had variable prior hypergravity experience; all were trained in anti-G straining technique (AGSM). The two sonographically-inexperienced subjects underwent a brief <5min familiarization with the ultrasound probe, user interface, and desirable viewing window immediately prior to centrifugation; real-time coaching was provided. Ultrasound images were correlated to symptoms, audiovisual monitoring, and hemodynamic data. **RESULTS:** All subjects were successful at obtaining ultrasound images with adequate capture of windows of

interest. The handheld ultrasound performed as desired, though probe overheating prematurely ended imaging efforts during all attempts. Subxiphoid cardiac ultrasound was additionally obtained by only the most experienced subject, with imaging efforts again limited by probe overheating. Subxiphoid imaging was associated with variable quality of imaging due to probe displacement from AGSM-related muscle contraction and the subject noted transient (<1d) discomfort after imaging in the subxiphoid region. **DISCUSSION:** We provide a successful demonstration that handheld sonographic technique is compatible with hypergravity exposure, and even individuals with minimal or no ultrasound experience can obtain usable images under centrifuge conditions. We further demonstrate video visualization of AGSM's effects on vasculature. Cardiovascular ultrasound images under hypergravity can be used for training and visualization of effectiveness of AGSM as well as better understanding of the physiological changes occurring under hypergravity including anatomical cardiovascular deformation in hypergravity conditions.

#### Learning Objectives

1. The audience will learn about challenges associated with sonographic imaging during centrifugation.
2. The audience will have the opportunity to see video results of sonographic efforts performed under human centrifugation.

### [129] CONTINUOUS GLUCOSE MONITORING IN ASTRONAUTS ON INSPIRATION4

Nicolas Heft, Charles Tsao, Jaime Mateus, Anil Menon  
SpaceX, Hawthorne, CA, United States

(Original Research)

**INTRODUCTION:** This case report describes the use of continuous glucose monitoring during space flight. Traditionally, astronaut candidates have undergone a rigorous selection process and have been subject to a range of disqualifying medical conditions, including diabetes mellitus. With the maturation of commercial spaceflight there is an opportunity to expand the envelope of medical conditions that are safely manageable in space. **METHODS:** In this case we discuss the use of a continuous glucose monitor (CGM), as worn by two of the Inspiration4 crew while in-flight. Two Dexcom G6 CGM devices were used to record data during this 3-day mission. The CGM devices were donned on flight day (FD) 2 and worn for about 2 days. The devices successfully transmitted data every 5 minutes, as programmed. **RESULTS:** The devices operated successfully and levels ranged from 62 to 151, with an average and standard deviation (SD) of  $97 \pm 16$  mg/dL for one crew member; and from 55 to 156 with an average and SD of  $95 \pm 20$  mg/dL for another. Both crewmembers exhibited two noticeable spikes in glucose levels on FD3 ranging from 150 to 160 mg/dL. **DISCUSSION:** While a precise record of the timing of food consumption per crew member is not available, the spikes appear to follow meals on FD 3. The biggest limitations in this report are that no pre-flight baseline data collection was obtained and no in-flight finger prick calibration was available. This makes it difficult to infer the accuracy of glucose readings. However, the overall range is within what might be expected and the glucose spikes correlate to the largest meals that the crew consumed while on-orbit. Future work can expand on this by validating the accuracy of the CGM in-orbit by comparing readings with a finger-prick calibration, this is especially relevant since the Dexcom 6 device measures glucose levels in the interstitial fluid and those could be affected by microgravity-induced fluid shifts. If validated, the ability to provide real-time glucose analysis such as that provided by continuous glucose monitoring would allow flight surgeons to have the confidence in being able to treat and monitor 10.4% of the world's population currently barred from space-flight due to their diabetes.

#### Learning Objectives

1. The audience will learn that interstitial glucose levels in astronauts were within the normal physiological range over the 2 days the data was recorded.

2. The audience will learn that there were no major hypo- or hyperglycemic events recorded with this method of data collection.

Monday, 05/22/2023  
Nottoway & Oak Alley

4:00 PM

### [S-24]: PANEL: SELECTED CASES AND NOVEL SOLUTIONS FROM JUNIOR FLIGHT SURGEONS

Chair: Robert Barbera

**PANEL OVERVIEW:** This panel is meant to highlight the accomplishments and perspectives of Junior Flight Surgeons in the Department of Defense. We will present a range of topics to include interesting aeromedical cases, highlight unique problems and their solutions, and provide a platform for discussion of these topics. The Junior Flight Surgeons have a unique perspective on how institutional policy is implemented at the clinic level to deliver readiness to the warfighter. It offers an opportunity for experienced and the inexperienced in the field to speak to one another directly as we chart a course together to the future of flight medicine. From these presentations, we hope to link these junior physicians with stewards interested in their perspective for future projects and AsMA contributions. In the past, this panel has been widely anticipated and well attended by previous AsMA delegations. We hope to continue this tradition through the quality submissions, lectures, and lessons identified from this panel.

### [130] MAINTAINING A MILITARY TREATMENT FACILITY BLOODBORNE PATHOGEN PROGRAM

Robert Barbera<sup>1</sup>, Joseph Yabes<sup>2</sup>

<sup>1</sup>San Antonio Uniformed Services Health Education Consortium, San Antonio, TX, United States; <sup>2</sup>Infectious Disease Department, Brooke Army Medical Center, San Antonio, TX, United States

(Education - Program/Process Review)

**BACKGROUND:** Protecting healthcare workers from bloodborne pathogens is an essential topic of occupational medicine that can land within the responsibilities of junior flight surgeons. Understanding the underlying concepts of bloodborne pathogens and needle stick injuries can help providers set up or maintain their institution's bloodborne pathogen program in accordance with AFI 44-108 (Infection Prevention and Control Program) and OSHA 29 CFR (Occupational Safety and Health Standards). **OVERVIEW:** Due to a series of needle stick incidents at a medium size military treatment facility, staff were asked to analyze the incidents and update the base bloodborne pathogen program. Cause analysis showed an in-place program with limited shared knowledge and unavailable resources to take correct measures to protect healthcare workers. Study was conducted including military infection control courses and national clinician consultation center. This education emphasized the importance of early recognition, source patient testing for rapid HIV, and urgent counseling of healthcare worker on post-exposure prophylaxis. The process was also updated to support compliance with reporting, increased availability of resources, and access to appropriate follow up care. This effort led to compliance with AFI/OSHA requirements and safe working environments for the MTF personnel. **DISCUSSION:** Needle sticks are a common medical workplace injury; flight surgeons and occupational physicians need to understand the basics of appropriate urgent action to mitigate risks of bloodborne pathogens. With this knowledge junior flight surgeons can tackle this occupational health challenge with confidence and maintain their base infection control program. The specifics of this presentation will be applicable to any U.S. healthcare facility and the underlying concepts are true at all global institutions.

#### Learning Objectives

1. The audience will learn about the requirements in AFI 44-108 and OSHA 29 CFR to provide for healthcare worker protection in bloodborne pathogen incidents.

2. The audience will learn about the health threats of common blood-borne pathogens; furthermore appropriate preventive measures, post-exposure prophylaxis, and clinical follow up will be discussed.
3. The audience will learn about challenges in maintaining a blood-borne pathogen program at a MTF and recommendations in process improvement and communication of resources.

### [131] LESSONS FROM A FIRST ASSIGNMENT FLIGHT SURGEON AT A GEOGRAPHICALLY SEPARATED UNIT

Spencer Fray

*U.S. Air Force, APO, Armed Forces - Europe, Canada, Middle East, Africa, United States*

*(Education - Case Study)*

**BACKGROUND:** The flight surgeon career field in the U.S. Air Force (USAF) is currently undermanned. The USAF has developed and implemented the Operational Graduate Medical Education (OGME) program to increase the number of residency-trained flight surgeons in the service. Due to the high demand for residency-trained assets, OGME graduates may find themselves being placed in remote, high-priority assignments directly out of the medical school and residency training pipeline. Some of these assignments include working at Geographically Separated Units (GSUs), which typically only have one flight surgeon billet. While the OGME program incorporates dedicated flight medicine training, there are many aspects of working in a GSU that OGME graduates may not encounter until practicing in the field.

**OVERVIEW:** I graduated from the OGME program in 2021 with my first assignment being a two-year tour at a GSU in Europe as the squadron's only flight surgeon. Some of the challenges that I encountered included completing mission qualification upgrade training, obtaining flying hours, establishing clinic operating instructions to include aeromedical evacuation planning for critical and psychiatric patients, validating the host nation's secondary healthcare facilities for U.S. military use, coordinating cold chain shipment and storage of the COVID-19 vaccine, and figuring out how to conduct sexual assault medical forensic exams (SAMFE) without any SAMFE-trained providers in country. Many of these challenges are not altogether uncommon for providers at GSUs. This presentation will discuss lessons learned over the past year of working at a GSU to help highlight the unique challenges young flight surgeons can face in that practice setting. **DISCUSSION:** More USAF flight surgeons will matriculate through the OGME program as it continues to develop. The transition from training to operational practice may continue to have unique challenges for OGME graduate due to the positions for which they are needed. Having discussions about what those challenges are will help shape the training in OGME programs and better prepare graduates to practice flight medicine in remote settings.

#### **Learning Objectives**

1. The audience will learn about challenges of working as a flight surgeon in a remote, military environment.
2. The audience will be able to better understand how to equip young flight surgeons for practicing in remote military environments.

### [132] SELECTED CASES AND NOVEL SOLUTIONS FROM JUNIOR FLIGHT SURGEONS - AVT-SQUADRON AFFILIATION AT NAS PAX

Michael Yue

*U.S. Naval Test Pilot School, Patuxent River, MD, United States*

*(Education - Program/Process Review)*

**BACKGROUND:** Recent alignment of clinic-based AVTs with squadrons has increased the overall ability of Naval Health Clinic Patuxent River (NHCPR) to provide a higher standard of care more efficiently. NHCPR is the health clinic at Naval Air Station Patuxent River (NAS PAX), home to five test squadrons with both military and civilian staff. At clinic, each squadron's Flight Surgeon works with six Aviation Medical Technicians (AVTs) who are navy corpsmen assigned to the clinic. AVTs are aviation-medicine specialized corpsmen. Prior to AVT alignment to squadrons, the transition to the Defense Health Agency reduced clinic staffing and resulted in schedule changes, increased time to complete flight physicals, and decreased appointment availability. While this new affiliation with squadrons does not

formally assign AVTs to specific squadrons, their specialization leads to benefits for patients, the clinic, and military operations. **OVERVIEW:** Different commands and flight surgeons have different flight medicine needs, which are particularly complex given the military and civilian composition of test squadrons. To streamline care, flight surgeons at NAS PAX worked with clinic leadership to have each AVT affiliated with a squadron. While the AVTs still belong to clinic, they specialize in the administrative knowledge for specific squadrons. **DISCUSSION:** This effort has benefitted squadrons, corpsmen, and the clinic. Squadron medical readiness has increased. Flight physical processes are smoother. Visit volume and wait times at clinic have decreased. In turn, AVTs have become familiar with flight operations, experience increased job satisfaction, and have opportunities to do aviation-related training. At clinic, corpsmen affiliated with squadrons coach and mentor other corpsmen, increasing skill and capacity at the clinic at large. This structure provides higher-quality care across the base, improving operational planning and readiness. This paper further details the challenges and solutions of implementing AVT-squadron affiliation and details potential application to other military medicine clinics.

#### **Learning Objectives**

1. The audience will appreciate the challenges of a centralized health-care staffing structure for a military medical clinic serving multiple operational commands.
2. The audience will understand the benefits of affiliating non-provider medical staff with tenant commands.

### [133] ESSENTIAL FLIGHT SURGEON KNOWLEDGE AND ACTIONS IN CASE OF A CASE OF CAISSON'S DISEASE

Joel Reimer, Gregory Trifilo, Jeffrey Kinard

*460th Medical Group, Buckley Space Force Base, Aurora, CO, United States*

*(Education - Case Study)*

**INTRODUCTION:** This case report describes a USAF fighter pilot who experienced a Type II Spinal Decompression Sickness (DCS) injury while SCUBA diving, resulting in lower extremity paralysis and urinary retention.

**BACKGROUND:** While the concern for neurological DCS from aviation decompression events is frequently discussed and vigilantly monitored, hyperbaric decompression events from recreational underwater activities are less frequently encountered but can pose a significant risk for aviators. Both have an intricate recovery and aeromedical waiver process, requiring the involved Flight Surgeons to be familiar with procedures for emergency and follow-up care along with return-to-fly guidelines. **CASE PRESENTATION:** The subject is a previously healthy 48-year-old F-16 pilot who suffered a SCUBA related Spinal DCS injury while on vacation in Guam. Immediately upon exiting the water, he was noted to have an ataxic gait and altered mental status. He was brought to the local medical facility, where he underwent emergency hyperbaric O2 therapy (TT6) with eventual return to normal mentation but persistent lower extremity weakness and urinary retention. He returned to his home station, where he underwent intensive progression of inpatient and outpatient physical therapy with gradual return of motor function over the course of 4 months. Neurologic bladder dysfunction also improved with time, requiring progression from foley to scheduled intermittent self-catheterization, and eventually to full independent urination without evidence of abnormal postvoid residual urine or hydronephrosis. At 6 months post-injury and after near complete recovery, an aeromedical waiver was granted for return to flying class II duties. **DISCUSSION:** This case highlights the risks associated with SCUBA diving to the military aviator, as well as the need for Flight Surgeons to be prepared for the emergency management of neurological DCS and to be knowledgeable of local resources to aid in the recovery. This case also provides the opportunity to discuss the pathophysiology of decompression events, contributing factors to risk and recovery, as well as aeromedical concerns and nuances for safely returning a flyer to duty.

#### **Learning Objectives**

1. The audience will understand the criteria for diagnosis of acute Type II (Neurological) DCS and the required treatment for the condition.
2. The audience will gain an understanding of the long-term clinic management and resource requirements for aviators with continued neurological sequelae of Type II DCS.

3. The audience will understand the clinical requirements and process for USAF aeromedical waiver approval for neurological DCS.

### [134] OPERATIONAL TO EDUCATIONAL, SME TO SGP

Angelica Fullerton

U.S. Air Force, Pensacola, FL, United States

(Education - Case Study)

**INTRODUCTION:** This presentation discusses the varying roles junior flight surgeons find themselves in, and some tips for success.

**BACKGROUND:** Junior flight surgeons, including those straight out of training and without a residency, find themselves in a variety of assignments. This can be overseas, involve a variety of special duties, and involve every possible mission. With only months of training, these flight surgeons often struggle to succeed, resulting in burnout, suboptimal care, and detriments to the mission and flying safety. **CASE PRESENTATION:** My first assignments out of my flight surgeon training were a short tour with a fighter squadron in Kunsan, South Korea, and then as SGP of the Air Force Undergraduate Combat System Officer training program. The first assignment was very mission focused, with a strong historical culture, and small patient population. The second assignment is a large training group, with significant MAJCOM level visibility and a young population without experience on flying status. Both assignments required significant learning and adaptation to deal with unique populations and requirements. **DISCUSSION:** While every assignment will be unique, there are common themes for what young flight surgeons can do to grow and what more senior flight surgeons can do to help them succeed. Seeking out (or being) mentors, humility, and adaptability are essential to the success of junior flight surgeons. Finally, there are some key opportunities when dealing with young flyers, especially the opportunity to build a healthy trust and relationship with flight medicine, that are not to be missed in any assignment.

#### Learning Objectives

1. Appreciate the variety of assignments and responsibilities that junior flight surgeons undertake.
2. Understand some keys to success for junior flight surgeons, both universally and in a training environment, and how senior flight surgeons can aid in their growth.

**TUESDAY, MAY 23, 2023**

**Tuesday, 05/23/2023**  
**Grand Ballroom A-B-C**

**8:30 AM**

### 9TH REINARTZ LECTURE

**Ansa Jordaán, M.B.Ch.B., B.Sc.(Hons.)**  
**Aerospace Medicine, DOMH**

**"Civil Aviation in the Future: Key Issues to be Addressed"**

**Tuesday, 05/23/2023**  
**Grand Ballroom A-B-C**

**10:30 AM**

### [S-25]: PANEL: CLINICAL AND RESEARCH INSIGHTS INTO SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME (SANS)

**Chair: Tyson Brunstetter**

**Co-Chair: Mary Van Baalen**

**PANEL OVERVIEW:** First discovered in 2005, Spaceflight Associated Neuro-ocular Syndrome (SANS; formerly known as "VIIP") is a condition unique to long-duration spaceflight. SANS is associated with a multitude of

signs such as optic disc edema and retinal nerve fiber layer thickening; globe flattening; shifts in refractive error; and chorioretinal folds. Other potential signs include brain anatomical changes, retinal cysts, retinal pigment epithelial detachments (PEDs), and optic nerve sheath distention; however, it is unclear whether these signs are truly associated with SANS. While the pathogenesis and pathophysiology of SANS remain elusive, several theories exist. This panel will explore the latest technologies in detecting, diagnosing, and monitoring SANS; present recent SANS/neuro-ocular clinical surveillance and research findings from long-duration crewmembers and terrestrial subjects; and explore potential physiological factors that may contribute to the generation of additional neuro-ocular risk during exploratory spaceflight.

### [135] SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME (SANS): 2023 CLINICAL UPDATE

**Tyson Brunstetter<sup>1</sup>**, Sara Mason<sup>2</sup>, Wafa Taiym<sup>3</sup>, C. Robert Gibson<sup>4</sup>, Mary Van Baalen<sup>1</sup>, Ann Tsung<sup>3</sup>, William Tarver<sup>1</sup>

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(Original Research)

**INTRODUCTION:** Spaceflight Associated Neuro-ocular Syndrome (SANS) is unique to long-duration spaceflight (LDSF). Two-thirds of LDSF astronauts present with the earliest indication(s) of SANS, defined as development of any of the following in  $\geq 1$  eye during or immediately following spaceflight (SF): 1) optic disc edema (ODE;  $\geq 20$  micron increase in peripapillary total retinal thickness [Delta TRT]); 2) chorioretinal folds; 3) globe flattening; and 4) refractive error shift ( $\geq +0.75$ D). Each presents risk to a crewmember's vision and mission effectiveness; however, it is not yet known what severity and/or duration might lead to acute or permanent impacts to ocular anatomy or visual performance. Brain anatomical changes also occur during LDSF and are being monitored; however, these changes have not yet been associated with functional decrements or with SANS. **METHODS:** Data were obtained from clinical records and subject matter experts. Areas of interest include: 1) prevalence of SANS, 2) ongoing SANS clinical efforts, and 3) SANS clinical thresholds. **RESULTS:** Prevalence of SANS findings in USOS LDSF crewmembers is: 64% for ODE, 15% for chorioretinal folds, 26% for globe flattening, and 14% for hyperopic shifts ( $\geq +0.75$ D). **DISCUSSION:** All SANS diagnostic hardware are performing nominally onboard the International Space Station (ISS). The Goggle-Based Visual Field (GBVF) device has completed clinical validation testing at Ohio State University and is planned for parabolic flight testing (2022-23) and an ISS technology demo (2024). Four SANS Clinical Thresholds are now established: 1) "Earliest Indication of SANS" – Introduced in 2020, see definition, above; 2) "Clinically Concerning SANS" – Development of any of the following during or immediately following SF: a) ODE ( $\geq 55$ -micron Delta TRT and/or Frisén grade  $\geq 1$ ), b) sharp chorioretinal folds in/near the macula, or c) moderate globe flattening; 3) "Pathological SANS with Acute Functional Impact" – Development of any of the following during or immediately following SF: a) visual field (VF) loss, b) distorted central vision, or c) shift in refractive error beyond power of available optical correction; 4) "Pathological SANS affecting Long-Term Health" – Development of any of the following during or following SF: a) permanent VF loss, b) reduced retinal nerve fiber layer thickness, c) permanently distorted central vision, d) atrophy of retinal pigment epithelium or photoreceptors, or e) choroidal neovascularization.

#### Learning Objectives

1. Understand the new and previously established clinical thresholds of Spaceflight Associated Neuro-ocular Syndrome (SANS), their rationale.
2. Understand the risk of SANS to the eyes, vision, and mission of astronauts during long- and extended-duration spaceflight missions.