

WEDNESDAY, MAY 24, 2023

Wednesday, 05/24/2023
Grand Ballroom A-B-C

8:30 AM

[S-44]: PANEL: COORDINATED NASA APPROACH FOR THE DEVELOPMENT OF MEDICAL CAPABILITIES AND TECHNOLOGIES FOR DEEP SPACE EXPLORATION

Chair: Kris Lehnhardt

Co-Chairs: Rahul Suresh, Moriah Thompson

PANEL OVERVIEW: Building upon the success of the last two decades of human spaceflight medical operations onboard the International Space Station (ISS), NASA now must start to evolve to a deep space medical operations paradigm. This new paradigm will include myriad challenges such as communication delays and blackouts, infrequent or unavailable resupply opportunities, potentially significant vehicle resource constraints, and delayed or non-existent evacuation options. To overcome these challenges, two separate but highly coordinated NASA groups are working together to develop and test solutions to these problems: the Exploration Medical Capability (ExMC) Element of the NASA Human Research Program and the Exploration Medical Integrated Product Team (XMIPT) of the Environmental Control and Life Support System – Crew Health and Performance Systems Capability Leadership Team. Although the work of these two groups is very complementary, ExMC generally focuses more on research and early technology development work while the XMIPT works on maturing and integrating new medical capabilities for exploration. During this panel, these two groups together will present details on how medical capability gaps are defined and addressed, a new work plan in development to increase medical autonomy in spaceflight, a technology maturation effort to generate intravenous fluids from potable water onboard a spacecraft, multiple new technology demonstrations of in-situ laboratory analysis capabilities, and new onboard tools to advance medical care for deep space missions.

[231] IDENTIFYING AND CLOSING MEDICAL CAPABILITY GAPS FOR HUMAN SPACEFLIGHT MISSIONS BEYOND LOW EARTH ORBIT

Moriah Thompson, Kris Lehnhardt, Ben Easter, Jay Lemery, Rahul Suresh

NASA, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: Features of human space missions beyond low Earth orbit such as increasing distance from Earth, lack of real-time communication, and limited or no evacuation or resupply capability are expected to drive an increase in medical risk and require crews to operate in an increasingly autonomous fashion. A diverse set of stakeholders at NASA are seeking to fund the development of concepts of operations, medical requirements, and medical capabilities for such missions. However, a systematic approach to identification of current medical capability gaps and a strategic framework to gap closure is needed. **OVERVIEW:** The Exploration Medical Integrated Product Team (XMIPT) has developed a list of eight high-level medical capability gaps and associated activities required for gap closure. The list was derived based on inputs from subject matter experts at NASA including flight surgeons, other clinical providers, as well as operational and research communities regarding medical capabilities required to support humans' mission to the Moon and Mars surface. Responses were reviewed and distilled to identify common themes across capabilities. To ensure alignment with established human system risks, the gap list was further refined based on inputs from NASA's Human

System Risk Board. Relevant medical gap closure activities outside of those funded by the XMIPT were identified through solicitation of inputs from Elements of NASA's Human Research Program (particularly Exploration Medical Capability), the broader medical operations community, and other stakeholders. This medical capability gap list is reviewed and updated regularly as new information becomes available or new stakeholders are identified. **DISCUSSION:** The medical capability gap list has matured to include a large group of NASA stakeholders and development activities. This has enabled articulation of priorities to funding entities and programmatic stakeholders, while serving as an accessible resource summarizing gap closure activities, relevant programmatic infusion points, and opportunities for collaboration between stakeholders. This presentation will provide an overview of the eight NASA medical capability gaps and their associated gap closure activities.

Learning Objectives

1. Understand the ways in which human exploration missions to Mars will increase medical risk relative to missions to low Earth orbit.
2. Describe the benefits of a medical capability gap list for exploration missions.

[232] EARTH INDEPENDENT MEDICAL OPERATIONS- FOUNDATIONS TO ADVANCE LONG DURATION MISSION HEALTH

Jay Lemery, Kris Lehnhardt, Ben Easter

NASA Exploration Medical Capabilities, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: Earth Independent Medical Operations (EIMO) embodies a novel approach for long duration mission medical operations and will necessitate new innovations as well as draw upon validated work to support autonomous medical systems. **OVERVIEW:** Defining parameters of EIMO include limited medical resources with few resupply opportunities; communication disruptions; and few windows for evacuation. EIMO is an emerging paradigm to advance integrated, autonomous medical systems to optimize human health and performance for long-duration missions. For many years, ExMC has endeavored to augment the capacities of in-flight providers as well as ground-based support. Here we outline these constituent efforts which provide a foundation for integration into future EIMO work. **DISCUSSION:** For years, ExMC has embraced a multi-pronged strategy to advance autonomous medical operations. In so doing, it has established a foundational body of work to inform the future EIMO work for long-duration missions. We cite the following as examples: *Autonomous Medical Officer Support* (AMOS) demonstrated ultrasound performance by non-medical crewmembers without real-time ground support. The codification of *Identification of Medical Training Methods for Exploration Missions* provided an inventory of augmented capacities to astronauts with limited medical training. Point of care laboratory testing and in-situ medical analysis were performed through validated devices (ex: *rHealth and Hemocue*), and validated real time serologic and pharmacologic testing. Successful demonstrations of inventory management/medical consumables tracking and in-situ IV fluid generation provided evidence of enhanced capabilities and resources. The Tempus-ALS monitor demonstrations, utilizing medical scenarios to validate integrated diagnostics in the form of patient monitoring and ultrasonography provides proof-of-concept for rapid crew access to data from all on-board systems, leading to better-informed, real-time, autonomous decisions. Finally, the clinical decision support work supported by ExMC (including concept of operations and data architecture/requirements) has yielded invaluable insights into autonomous systems and has served as a stepping stone to a fully integrated data architecture. As the imperative to develop EIMO will accelerate in the near term, 'lessons learned' from disparate and historic ExMC efforts will be critical in taking this next step for long duration spaceflight.

Learning Objectives

1. Understand the constituent efforts which will inform the work of EIMO.
2. Understand the strategy and rationale for the novel paradigm of EIMO.
3. Understand the challenges of health and wellness for long duration spaceflight.

[233] PRODUCING STERILE IV FLUIDS ON THE INTERNATIONAL SPACE STATION: INTRAVENOUS GENERATION MINI (IVGEN MINI) PROJECT

Courtney Schkurko¹, Rahul Suresh², Moriah Thompson², Tyler Hatch², Alexandru Mezin³, Alex Salimian³, Brian Hromco³

¹NASA Glenn Research Center, Cleveland, OH, United States; ²NASA JSC, Houston, TX, United States; ³ZIN Technologies, Middleburg Heights, OH, United States

(Education - Program/Process Review)

BACKGROUND: Expiration dates of commercially available IV fluids are shorter than the anticipated duration of a Mars surface mission and the volume needed to meet medical needs may be limited by mass and volume constraints. Production of medical grade IV fluids from the potable water supply of an exploration vehicle or habitat would reduce medical risk and the mass and volume footprint of the medical system. In 2010, the Exploration Medical Capability Element of NASA's Human Research Program funded the Intravenous Fluid Generation (IVGEN) International Space Station flight demonstration that produced two 1.5 L bags of sterile IV fluids from vehicle potable water. **OVERVIEW:** NASA's Exploration Medical Integrated Product Team is funding the IVGen Mini project to miniaturize the original IVGEN, increase the technology readiness level (TRL) of the system to 6, and conduct a flight demonstration. The design features inlet ports for vehicle potable water and 26% concentrated saline solution. These are pumped through the Fluid Generation Module via electrically driven peristaltic pumps. In this module passive mixing of fluids is performed to create 0.9% normal saline. Inline conductivity and flow sensors provide feedback control to achieve appropriate saline concentrations. Fluid then travels through the Filter Box Assembly where deionization occurs and filters remove bacteria, endotoxins, air and sterilize the solution. The final product is collected in a sterile 1 L bag. The unit is designed to operate on battery power. Two batches of ten 1 L bags will be produced in-flight three months apart to assess the robustness of the system and its consumables. Some IV fluid will be returned to Earth and analyzed to determine compliance with U.S. Pharmacopeia standards for IV fluids. **DISCUSSION:** Compared to the IVGEN, the current design reduces system mass and volume, eliminates the need for gaseous nitrogen, a pressure chamber, or a dedicated mixing mechanism, increases fluid volume produced, enables portability by enabling the ability to operate on battery power, and allows rapid changeout of system consumables (Filter Box Assembly). Additional development efforts to mature the system to TRL 7 include in-flight battery testing, radiation hardening of components, and further miniaturization.

Learning Objectives

1. Understand the IVGEN Mini design and how it enables production of sterile intravenous fluid in a microgravity environment using available vehicle resources (i.e., potable water, electricity).
2. Describe how the current IVGEN Mini design differs from the original IVGEN hardware flown by the NASA Human Research Program in 2010.

[234] AN IN-SITU LABORATORY ANALYSIS CAPABILITY FOR EXPLORATION SPACEFLIGHT

Courtney Schkurko¹, Gail Perusek¹, Emily Nelson¹, Kimesha Calaway², Rachael Miller², Russell Valentine², Brian Crucian³, Benjamin Easter³, Kris Lehnhardt³

¹NASA Glenn Research Center, Cleveland, OH, United States; ²ZIN Technologies, Middleburg Heights, OH, NASA; ³NASA JSC, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: Point-of-care medical diagnostic technology has been identified by NASA as a critical need for future human space exploration to enable diagnosis, monitoring, and treatment of spaceflight medical conditions. Future deep-space exploration missions will entail unprecedented and complex challenges including limitations in mass,

volume, power, and consumables, and an inability to return biological samples back to Earth for analysis. Exploration Laboratory Analysis (ELA) technology maturation and in-space demonstrations of candidate technologies are needed for the development of exploration medical systems that will optimize crew health and performance monitoring. **OVERVIEW:** The Exploration Medical Capability (ExMC) Element of the NASA Human Research Program has developed a Concept of Operations and set of recommended requirements for an Exploration Laboratory Analysis capability. Recently, ExMC has demonstrated two commercially available portable analyzers that underwent minor modifications in order to function in the spaceflight environment of the International Space Station (ISS). In 2021, a five-part differential white blood cell analyzer provided the first-ever whole blood analysis capability in spaceflight, and the subsequent successful demonstration of a more comprehensive biomarker analyzer in 2022 proved out this critical in-situ analysis capability. In the future, ELA technologies will help to enable crew medical autonomy by providing broad capabilities for measurement of cells, cell counts, biomarkers, microorganisms, electrolytes, and enzymes – ideally with minimal consumables, and minimal biological sample volume – for a variety of sample types including blood, urine, sweat, and saliva. These technologies will need to meet acceptable clinical standards for accuracy and precision, as well as higher-level certification standards and/or applicable international standards. **DISCUSSION:** ELA technologies will enable astronauts on deep-space missions to diagnose, monitor, and treat spaceflight medical conditions in-situ without the need for biological sample return. This presentation will outline the ELA Concept of Operations, an overview of the recommended requirements necessary for an ELA exploration medical capability, and the results of the recent successful technology demonstrations on the ISS of two modified commercial laboratory analyzers.

Learning Objectives

1. Understand the need for an Exploration Laboratory Analysis (ELA) capability and how it enables point of care diagnostics, monitoring, and treatment and its role in advancing medical system design for exploration beyond low-Earth orbit.
2. Discover how recent successful ISS technology demonstrations flown by the NASA Human Research Program of modified commercial laboratory analyzers contribute to an enhanced understanding of recommended medical system requirements and increase technology readiness.

[235] IDENTIFYING TECHNOLOGIES FOR EXPLORATION MEDICAL SYSTEMS – THE MEDICAL EXPLORATION DEVELOPMENT AND IMPLEMENTATION SCOPING (MEDISCOPE) PROJECT

Rahul Suresh¹, Moriah Thompson¹, Courtney Schkurko², Alexandru Mezin³, Tyler Hatch², Alex Salimian³

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(Education - Program/Process Review)

BACKGROUND: Exploration missions to Mars will require increasing crew autonomy and independence to account for communication delays and loss of real-time ground support. Medical system design and concepts of operations will need to be redefined to transition activities currently managed by the ground onto the vehicle and crew. Meanwhile, commercial industry, both in and out of the healthcare sector, has seen significant investment and development in "smart" systems designed to enable various modes of autonomous operations. **OVERVIEW:** NASA's Exploration Medical Integrated Product Team (XMIPT) developed and maintains a list of capability gaps identifying the necessary, but currently unrealized, capabilities for these mission concepts. The MEDIScope project sought to determine stakeholder requirements and identify candidate technologies for three of these capability gaps: an Automated Medical Inventory System (AMIS), a Multifunctional Integrated Medical Device (MIM Device), and an

Exploration Electronic Health Record (xEHR). Concepts of operations and functional requirements were developed by the project team and refined with inputs from internal stakeholders at NASA Johnson Space Center. These proposed concepts were then used to inform a market survey with an expressed goal of assessing the feasibility of utilizing commercial-off-the-shelf (COTS) items to provide these capabilities. **DISCUSSION:** The MEDIScope project enabled development and refinement of the concepts for these capabilities and reviewed commercially available technologies that might make those systems possible. This paper will introduce some of the operational concepts assessed as a part of this effort and will discuss some of the evaluation criteria, challenges, and opportunities associated with utilizing COTS items for exploration medical system development.

Learning Objectives

1. Describe three key medical capabilities identified by XMIPT to enable an exploration medical system.
2. Understand the opportunities, challenges, and figures of merit of medical commercial-off-the-shelf products for spaceflight.

Wednesday, 05/24/2023
Grand Ballroom D-E

8:30 AM

[S-45]: PANEL: PLANNING COMPREHENSIVE MEDICAL READINESS PROGRAM FOR FLIGHT SURGEONS

Chair: Talib Ali

Co-Chairs: Jason Burchett, Douglas Files, Paul DeFlorio

PANEL OVERVIEW: *Background: In addition to practicing clinical medicine flight surgeons perform a variety of operational and administrative tasks. Overview: The current panel will discuss how flight surgeons perform shop visits, work with fatigue countermeasures, prepare human factors briefings and perform food and water safety visits. Discussion: This panel will present recent information on recommended practices in performing non-clinical aerospace medicine tasks. Flight surgeons and other participants from different backgrounds will compare and contrast what they have learned. Through this process U.S. Air Force flight surgeons will complete requirements of the Comprehensive Medical Readiness Program for flight surgeons.*

[236] PLANNING FATIGUE COUNTERMEASURES

Russell Turner, Douglas Files, Jason Burchett
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: Professionals working in aerospace medicine may be expected to improve aviator performance. One important consideration in this area involves the use of medication to improve operator performance. Flight surgeons may prescribe hypnotic medications to help aviators sleep prior to a sortie and in special circumstances stimulants to improve performance during certain phases of flight. The current presentation will remind aerospace medicine professionals about sleep hygiene and the use of performance-enhancing medication in military aviators. **OVERVIEW:** Practitioners of aerospace medicine study physiologic effects and the potential risks of flight. In order to improve individual well-being and mission completion flight surgeons sometimes prescribe medication for use. Hypnotic medications may assist aircrew to sleep prior to a mission while other medications improve pilot alertness during critical phases of flight. This program will update flight surgeons and other participants on medical and other fatigue countermeasures. **DISCUSSION:** U.S. military forces often require annual training regarding the use of performance enhancing medication which this session can provide. Many other services also stress sleep hygiene issues and use performance-enhancing medication. This program will demonstrate potential techniques and will renew participants' requirements for the Comprehensive Medical Readiness Program (CMRP).

Learning Objectives

1. Discuss several features of using non-pharmacologic measures for military operations.
2. Consider pharmacologic vs. non-pharmaceutical measures for fatigue avoidance in operational settings.
3. Renew Comprehensive Medical Readiness Program (CMRP) requirements for the flight surgeon career field.

[237] PLANNING THROUGH WORKSITE SHOP VISITS

Douglas Files, Jason Burchett

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: Professionals in aerospace medicine maintain the well-being of various populations supporting flying missions. Performing worksite shop visits – particularly in concert with industrial hygienists – offer one method of achieving this goal. The current presentation will help aerospace medicine practitioners to maintain currency by participating in simulated shop visits. **OVERVIEW:** Frequent alteration of standards presents a challenge for professionals to maintain currency in readiness areas. The current program will update aeromedical professionals on how to perform various types of shop visits. Participants will participate in virtual shop visits and also discuss what to seek when at the worksite. **DISCUSSION:** Different types of shop visits may be performed by occupational health specialists as part of their attempts to improve the safety of employee populations. These shop visits are common practice in military and civilian settings. Participants will converse about the latest guidelines and techniques for performing a shop visit as well as the importance of shop visits to worker health.

Learning Objectives

1. Discuss useful practices for various types of shop visits with other participants.
2. Consider with other participants any updates on the flight medicine task of performing shop visits as part of an overarching occupational medicine program.
3. Renew and review USAF requirements for the flight surgeon Comprehensive Medical Readiness Program (CMRP).

[238] PLANNING HUMAN FACTORS BRIEFINGS

Jeffrey Lawson, Douglas Files, Jason Burchett

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: Professionals in aerospace medicine prepare and present briefings regarding safety, human factors, and other health topics to aircrew. The current presentation will aid professionals in sustaining readiness by participating in virtual human factors briefings. **OVERVIEW:** Commonly military flight surgeons present medical talks to aviators. These briefings occur during safety meetings, initial flying training or even after aircraft crashes. The current program will allow participants to review best techniques for flight surgeons to present human factors topics by providing an opportunity for individuals to prepare human factors briefing scenarios. **DISCUSSION:** One role aeromedical providers fulfill in the aviation community is to promote health and safety in aviation communities. The U.S. Air Force has decided that currency in human factors briefings should be performed on a recurring basis. Other services have similar recurring requirements. Attendees will discuss how to improve briefing styles.

Learning Objectives

1. Discuss aircraft mishap issues and how to brief aircrew about flying hazards.
2. Consider recommended and best practices regarding briefing styles and content.
3. Renew USAF requirements within the flight surgeon Comprehensive Medical Readiness Program (CMRP).

[239] PLANNING FOOD AND WATER SAFETY

Mary Brueggemeyer, Douglas Files, Jason Burchett
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: It commonly forms part of aerospace medicine professionals' duties to participate in public health and preventive medicine operations. Performing sanitation or food/water vulnerability assessments are some of the tasks they are asked to complete. The current presentation will help aerospace medicine professionals to maintain currency by participating in a virtual food or water vulnerability inspection. **OVERVIEW:** One responsibility aerospace medicine professionals take on is looking out for the safety and well-being of their assigned populations. Flight medicine experts commonly perform sanitation assessments in order to ensure flying safety and military mission completion. The present program will update aeromedical and allied professionals on sanitation and food/water vulnerability inspection issues through participants engaging in virtual inspections regarding water safety or epidemiology.

DISCUSSION: Sanitation site visits involving food and water sources should be performed regularly at airfields and other workplaces. Any gaps in these areas can severely obstruct mission completion and flight safety. The current program will give preventive medicine personnel a chance to discuss the latest guidelines in how to perform these inspections with experts. International colleagues will gain insight into United States food standards and how performing these inspections might improve aviation health in their own countries. Professionals from all disciplines will benefit from these sanitation inspection cases.

Learning Objectives

1. Relate new information regarding food and water safety, with a focus on military settings.
2. Consider and discuss solid practices regarding virtual and real sanitation visits.
3. Renew USAF requirements for the flight surgeon Comprehensive Medical Readiness Program (MCRP).

Wednesday, 05/24/2023

8:30 AM

Grand Chenier

[S-46]: PANEL: EVOLUTION OF CLINICAL CONTRIBUTIONS OF WOMEN IN OPERATIONAL MISSIONS IN AEROSPACE MEDICINE: LESSONS ON LEADERSHIP

Sponsored by Aerospace Nursing and Health Professionals Society

Chair: Marian B. Sides

Co-Chairs: Mary Cimrmanic, Allen Parmet

PANEL OVERVIEW: This panel is the third annual event of the Mary F. Foley Endowment. The fund was established in her honor to perpetuate her passion and lifetime career in profiling exceptional women in aerospace medicine, and to encourage other women to follow in her footsteps. Presenters will portray the dynamics of leadership of women through clinical contributions in operational missions, who broke barriers in their fields, and who distinguished themselves by persevering through adversity, courage, and determination. Their qualities and virtues through their profession journeys will be highlighted. The first presentation will profile Florence Nightingale, a nurse during the Crimean War, who cared for disease-infested British soldiers, introduced the concept of sanitation, elevated the principles of public health to national attention, creating the foundation for the profession of nursing. She is followed by the recognition

of Major Margaret C. McDonald, Matron-in-Chief, Canadian Army Nursing Services, nursing pioneer, historical figure in the Canadian Expeditionary Force, highest ranking woman in the British Empire WWI. The panel will highlight the heroic bravery of Lieutenant Mary T. Klinker, Air Force flight nurse, on board the C-5 Galaxy, Operational Babylift, who died in its crash during takeoff, while carrying over 180 helpless and terrified Vietnamese orphans to the USA. Presenters will honor Major Sandy Nestor, medevac nurse, USA, in Afghanistan, post "Dustoff," featuring Forward Surgical Teams and Cross-Disciplinary Critical Care Air Transport Teams, optimizing patient care in most extreme environments. Panel will also profile Dr. Elizabeth Bridges, nurse scientist, whose research enroute and whose combat casualty care illuminated our scientific knowledge base about the impact of the aerospace environment on patient care. The panel will culminate with a tribute to Cathy Dibiase, clinical nurse for NASA, by profiling her operational contributions, clinical research and substantial leadership during the U.S. Shuttle era. Cathy provided pre-flight and post-flight recovery care to astronauts during missions to and from the International Space Station. Leadership styles and unique qualities of these women pioneers will be discussed and how they navigated adversity and challenges will be recognized. This panel will offer illuminating insights, inspiration and mentoring opportunities in leadership development for the AsMA membership.

[240] FLORENCE NIGHTINGALE

J. Karen Klingenberg

U.S. Air Force, Williamsburg, VA, United States

(Education - Tutorial/Review)

Florence Nightingale was known as the 'Lady of the Lamp' and founder of modern nursing. She was also an effective leader in the face of adversity, a statistician, epidemiologist, logistician and prolific author who influenced the founding of medical schools for military physicians. Florence Nightingale, born into Britain's social elite, was vigorously educated at home. Nightingale challenged society's strictures to take up the masculine vocation of nursing. She taught herself nursing principles, attended the ill and, received four months of medical training at the institute at Kaiserswerth-am-Rhein in Germany. In 1854, in her middle thirties, she traveled to Turkey, to care for British soldiers fighting the Russians in the Crimea. With a mere 38 nurses under her, she provided medical care to a seemingly endless stream of troops wracked by frostbite, gangrene, and dysentery, that were crammed into 4 miles of beds not 18 inches apart. Her own quarters were cramped and infested with rodents and vermin. During January and February of her first winter, Nightingale saw 3,000 of the soldiers die, while she worked 20 hours per day and took the most-severe cases herself. In May of the following year, she developed a near-fatal illness (most likely brucellosis). Although she was urged to return to England, she remained with the Army during her convalescence and did not leave her post until the last soldier had left for home 21 months after her arrival. Nightingale is described as "a true pioneer in the graphical representation of statistics." She made extensive use of coxcombs to present reports on the nature and magnitude of the conditions of medical care in the Crimean War to Members of Parliament and civil servants who would have been unlikely to read or understand traditional statistical reports.

Learning Objectives

1. The audience will learn about how Florence Nightingale's graphical representation of statistics impacted and benefited operational medicine.
2. The audience will learn about three improvements to military medical care that she instituted.

[241] FOLEY ENDOWMENT PANEL

Katie Samoil

University of Calgary, Calgary, Alberta, Canada

(Education - Tutorial/Review)

TOPIC: Chairing the Canadian Nursing core during the First World War, 1914-1918, was only of Major Margaret MacDonald's significant operational leadership accomplishments. Born in 1873 in Bailey's Brook, Nova Scotia, Canada, Maj MacDonald chose a career of service, academia, leadership, and global deployment. After graduating nursing in 1895 from the New York City Hospital Maj MacDonald practiced in Panama, the Spanish-American War, and the Second Boer War in South Africa. In 1901 Maj MacDonald was appointed as one of the first full-time military nurses with the Canadians and recognized as one of the five founding members of the nursing service itself. Maj MacDonald advocated for standardized formal nursing education. Maj MacDonald also supported Orderlies and Physicians for work hours, recognition for service, medical benefits, and vacation. November 1914 saw Margaret MacDonald become the first woman in the British Empire to be awarded the rank of Major. A career of exemplary practice from 1895 to 1923 saw Maj MacDonald earn recognition from many sources. **APPLICATION:** Current training opportunities exist for physicians with a national boarded exam for Aerospace Medicine. It may be that with increased frequency of space missions the time has arrived for a recognized formal national education process for aerospace medicine nursing. The evaluation of standardized education as it relates to field advancement, and further necessitates the inclusion of nursing as a distinct and contributing health services profession within the aerospace medicine field may be a key factor in patient care.

Learning Objectives

1. By the end of this presentation participants will be able to recognize the role of formal education as it relates to standardized patient care, teamwork with previously known colleagues, and the advancement of a profession within a field.
2. By the end of this presentation participants will be able to describe three unique characteristics of aerospace medicine nursing, distinct from the practice of a Flight Surgeon, Crew Medical Officer, or Paramedic.

[242] MARY T. KLINKER: WHY DID WE NAME AN AWARD IN HER HONOR?

Cathy DiBiase

Kennedy Space Center, Titusville, FL, United States

(Education - Program/Process Review)

INTRODUCTION: Captain Mary T. Klinker was the only nurse from the Air Force Nurse Corps killed in Vietnam. AsMA has an award named in her honor that recognizes significant contributions to or achievements in the field of aeromedical evacuation. **TOPIC:** This presentation will highlight the short life of Mary Klinker. She was only 27 when she was killed in a C-5A Galaxy cargo transport plane crash during "Operation Baby Lift" at Tan Son Nhut Air Base in Saigon. Captain Klinker joined the Air Force Reserve following completion of her nursing training. A few years later she went into active-duty status, serving in the Philippines and at Travis AFB in California. Many that knew Captain Klinker, including her family, are no longer alive to share her deepest dreams, achievements and obstacles. However, based on the little that is written about her and what can be gleaned from her military record, she was an upstanding officer. When asked on her reserve status paperwork why she wanted to continue her active-duty status she stated, "I desire to remain in the Air Force to serve my country, further my education and gain experience... I believe I have adjusted well to the Air Force way of life." Also, to be presented will be the thoughts of those who have received the Klinker award. For several decades this award has been presented at the annual AsMA award banquet. Many who have received this award have been outstanding leaders in not only AsMA but ANAHPs. Their contributions led to their nomination. Each recipient of this distinguished award has some of Mary's drive as they have served our country, the space program, and many other aeromedical arenas.

APPLICATION: A life of service and commitment will be highlighted, with examples that can be followed.

Learning Objectives

1. Describe the commitment Mary Klinker had to her country.
2. Apply one example of contributions of the awardees to your life.

[243] THE EVOLVING CRUCIAL ROLE OF NURSING LEADERSHIP IN MEDEVAC CAPABILITIES AND SUSTAINABILITY: SPOTLIGHT ON MAJOR SANDY NESTOR

Annette Sobel

University of Missouri, Columbia, MO, United States

(Education - Tutorial/Review)

INTRODUCTION: Tactical medical evacuation has become a ubiquitous requirement for operational deployments. This capability has advanced substantially since the Vietnam era and 'DUSTOFF' platform to include iterative versions of Forward Surgical Teams and Critical Care Air Transport Teams, USA and USAF, respectively. **TOPIC:** This presentation will focus on the contributions of MEDEVAC nurse Major Sandy Nestor, U.S. Army, in Afghanistan and the synergy that nursing care and cross-disciplinary teams provide to optimize patient care in the most extreme conditions. **APPLICATION:** Effective leadership of cross-disciplinary teams in extreme environments is exemplified by the MEDEVAC platform. This environment requires rapid, adaptive leadership 'on-demand', irrespective of clinical rank or duty station. This presentation will profile the characteristics of effective leadership on a personal and team level, describing a continuum of communication, physical, intellectual, experiential and decision-making skills directly mappable to performance and patient outcome. The presentation will summarize the transferrable nature of these characteristics to other aspects of clinical medicine, with particular emphasis on extreme environments. In addition, opportunities for clinical research and technology insertion will be stressed that may enable and learn from leadership behaviors and outcomes, such as artificial intelligence, virtually augmented behavioral training and education, and sensor fusion technologies.

Learning Objectives

1. The audience will learn about the composite nature of effective leadership of MEDEVAC teams.
2. The participant will gain an improved understanding of the leadership challenges of extreme environments.
3. The audience will appreciate the evolution of medical capabilities and directly attributable improved patient outcomes enabled by effective MEDEVAC and aeromedical leadership.

[244] SCIENTIST, LEADER, ROLE MODEL - COL(RET) ELIZABETH BRIDGES, PHD, RN, CCNS, FCCM, FAAN

Tamara Averett-Brauer

711th Human Performance Wing, U.S. Air Force Aeromedical Research Lab, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Elizabeth Bridges is a distinguished scientist, leader, and critical care nurse, widely recognized across military and critical care audiences. Her rigorous yet approachable research has generated knowledge and evidence that impacts patient care at the bedside, at the litter side and at the plane side. **TOPIC:** Dr. Bridges is a tenured Professor at the University of Washington and Clinical Researcher. She's a Fellow of the Society of Critical Care Medicine and American Academy of Nursing, and Past President American Association of Critical-Care Nurses (AACN). She served 30 years in the USAF (active and reserve) as a clinician, scientist, and senior leader leading evidence-based approaches to critical war skills competencies. Her operational research experience in the Joint Combat Casualty Research Team directly contributed to the development of the DoD Trauma Registry demonstrating the value of real-time data collection leading to practice improvements in combat casualty care around the world. **APPLICATION:** Dr. Bridges' research is imminently practical and pragmatic, focusing on translation of knowledge across the combat casualty and aerospace medicine spectrum, with ramifications

for future operational environments. Dr. Bridges exhibited foresight and tenacity in her military-relevant research across the continuum of care from critical care hemodynamics at altitude to skin care during aeromedical evacuation. Her emphasis on translating research into practical tools led her to create the TriService Nursing Research Battlefield and Disaster Nursing Pocket Guide. She worked with the readiness community to physically distribute these guides to all nurses deploying to wartime theaters. She's a leading researcher in the evaluation of pressure relief devices in austere combat environments, including long-distance air medical transport. Dr. Bridges established a methodology to evaluate skin interface pressure on commonly used military litters and pads. She built a template that can be used to study devices or approaches to care in other operational environments (including microgravity, space, and prolonged care conditions). Dr. Bridges is the consummate role model of scientist, nurse, and leader, linking both military and civilian aerospace medicine clinical practice and evidence. **RESOURCES:** <https://nursing.uw.edu/person/elizabeth-bridges/> (accessed 20221031)

Learning Objectives

1. The participants will be able to describe one practical outcome of Dr. Elizabeth Bridges' research that made a difference in combat casualty care.
2. The audience will learn about Dr. Elizabeth Bridges' program of research and its practical applications across the combat casualty and aerospace medicine spectrum.

[245] "THIS CAREER WILL BE MY LIFE": AEROSPACE NURSE CATHERINE "CATHY" P. DIBIASE

Aubrey Florom-Smith

Stanford Health Care, Stanford, CA, United States

(Education - Tutorial/Review)

INTRODUCTION: Cathy DiBiase has contributed to crew health and mission success over three decades at NASA Kennedy Space Center. This presentation will highlight Ms. DiBiase's personal history and contributions to aerospace nursing clinical practice and leadership.

TOPIC: From an early age, Ms. DiBiase's intellect and drive for excellence were evident. An outstanding student, she obtained a Bachelor of Science in Nursing, and later practiced in intensive care, emergency care, and occupational health. A move to Central Florida prompted Ms. DiBiase to apply at Kennedy Space Center in 1994. She impressed: Ms. DiBiase was chosen over several other nurses, and a few weeks later, she supported the STS-65 landing. She soon realized that she could forge a rewarding career in aerospace nursing. In total, Ms. DiBiase supported 80 Shuttle missions by providing nursing care, education, and research, earning the respect of professional colleagues. As Lead Aerospace Nurse and a certified occupational health nurse, she now applies this vast experience through involvement in planning SpaceX Crew Dragon missions. Ms. DiBiase has received numerous awards and honors that demonstrate her effectiveness as a leader in aerospace. Active in AsMA, ANAHPS, and SMA, Ms. DiBiase champions aerospace nursing as an integral part of the space medicine team. As she notes when providing guidance to nursing students and others interested in aerospace nursing, it is an evolving, growing, interdisciplinary field - and Ms. DiBiase continues to lead the way. **APPLICATION:** Ms. DiBiase provides expert, specialized aerospace clinical care and education, and participates in important research focused on the health and safety of astronauts prior to flight and on launch day. Lessons learned from Ms. DiBiase's life and career are not just relevant to aerospace nurses, but to nurses and healthcare providers caring for patients in every setting. A true inspiration to the next generation of aerospace nurses, Ms. DiBiase exemplifies the best that nursing has to offer.

Learning Objectives

1. The audience will identify two leadership characteristics of Cathy DiBiase.
2. Learners will describe two key concepts of aerospace nursing clinical practice.

Wednesday, 05/24/2023
Napoleon Ballroom C1-C2

8:30 AM

[S-47]: PANEL: RESIDENT IN AEROSPACE MEDICINE (RAM) GRAND ROUNDS I

Chair: Albert Lee

Co-Chairs: Serena Aunon-Chancellor, David Miller

PANEL OVERVIEW: Resident in Aerospace Medicine (RAM) Grand Rounds consists of 6 clinical case presentations. Each case is presented by current RAMs who will review the clinical case, diagnosis, treatment pathway and current policies from different agencies. The aviator's aeromedical disposition and waiver or special issuance outcome (if applicable) will be discussed. These unique case presentations describe clinical aviation medicine as well as policy updates for common medical and/or mental health conditions encountered in the practice of Aerospace Medicine.

[246] SERONEGATIVE RHEUMATOID ARTHRITIS IN AN AVIATOR

Robert Wright, Cady Blasser

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case report describes a military aviator with an atypical presentation of rheumatoid arthritis (RA). **BACKGROUND:** RA is a chronic autoimmune disease characterized by progressive joint destruction with the potential for severe extra-articular manifestations and medication side effects of aeromedical concern. Early treatment with novel disease-modifying antirheumatic drugs (DMARDs) can prevent long-term progression and disability. **CASE PRESENTATION:** This case report describes a 38-year-old male aviator with a few months history of atraumatic bilateral pain in his shoulders and hips causing intermittent nighttime awakening, as well as night sweats and fatigue. His physical examination was unremarkable. Evaluation to rule out bony and hematologic malignancy, chronic infection, fatigue, and inflammatory/rheumatologic etiologies were normal except for mild edema in the hip and shoulder joints on MRI. A rheumatology consultant ultimately diagnosed him with seronegative RA. The aviator's RA flare was initially managed with a combination of prednisone and DMARDs including methotrexate (MTX) with folate and hydroxychloroquine (HCQ) with significant improvement in symptoms. **DISCUSSION:** This case highlights a severe rheumatologic condition affecting ~0.5% of US adults, with higher prevalence in women and adults over 50 years-old. Aeromedical risks are numerous, variable in severity, and can occur due to disease progression and/or treatment side effects. Progressive loss of fine-motor function and disability due to small joint damage can impair flight performance over time and be prevented with early treatment. Severe risks include spinal cord, brainstem, and vertebral artery compression due to neck flexion and extension during high G maneuvers due to cervical disease, such as atlantoaxial instability, which is common in RA. Other significant aeromedical risks include MTX-pneumonitis, HCQ-retinopathy and steroid-induced neuropsychiatric effects which will be analyzed using the AMRAAM. Aeromedical standards vary by agency. For example, the FAA allows prednisone and MTX but the USAF usually does not. Early diagnosis of RA is critical as prompt treatment with novel DMARDs can improve symptoms and prognosis, and enhance return to flight status. **DISCLAIMER:** The views expressed are those of the authors and do not reflect the official guidance or position of the United States Government, the Department of Defense or of the United States Air Force.

Learning Objectives

1. Participants will be able to discuss the aeromedical concerns surrounding the RA disease process and treatment modalities using the AMRAAM.
2. Participants will learn civilian and military aeromedical standards associated with RA.

[247] HEMOCHROMATOSIS FOLLOWING CMV INDUCED HEPATITIS IN A FLIGHT SCHOOL STUDENT: A CASE REPORT

Julissa Mendoza, Jelaun Newsome

Department of Aviation Medicine, U.S. Army Medical Center of Excellence, Fort Rucker, AL, United States

(Education - Case Study)

INTRODUCTION: This case report describes a military flight school student who was diagnosed with hemochromatosis following CMV induced hepatitis. **BACKGROUND:** Hemochromatosis is a disorder in which increased iron absorption can lead to total body iron overload. It may lead to a variety of complications including cardiac, CNS, and hepatic. Cardiac complications include dilated cardiomyopathy, heart failure, and conduction disturbances. Patients are also at an increased risk of CNS complications such as weakness and fatigue. Occupational factors, such as in aviation, in addition to history of hemochromatosis, vastly increases the risk of developing arthritis. Untreated hemochromatosis can lead to early death through various mechanisms such as heart failure, cirrhosis, and hepatocellular cancer. **CASE PRESENTATION:** The patient is a military flight school student who presented to the emergency department due to abdominal pain and was diagnosed with viral hepatitis due to CMV infection. His AST, ALT, and ferritin were noted to be 140 U/L, 264 U/L, and 603ng/mL respectively. After his liver associated enzymes began to trend to normal, his ferritin increased to 802 ng/mL. Further evaluation with ultrasound, CT, and MRI were normal. Upon further testing by gastroenterology, he was diagnosed with hemochromatosis. The patient was treated with monthly phlebotomy for 3 months, then every 3 months for 6 months until his ferritin levels returned to <100 ng/mL. The flight surgeon then submitted a request for a medical exception to policy (waiver). The exception to policy was approved by the Army, with a requirement of an annual iron panel. The patient began training without subsequent health related incident. **DISCUSSION:** Flight surgeons assess and perform risk mitigation; this case highlights a few considerations and complications of blood disorders in a flight school student. The flight school student in this case presented with an acute illness of viral hepatitis that may have been complicated by his previously unknown history of hereditary hemochromatosis. He was appropriately treated with phlebotomy and stabilized without need for further treatment. This case illustrates the various considerations a flight surgeon must contemplate when determining appropriate risk mitigation in the medical screening of flight applicants.

Learning Objectives

1. The audience will learn about the symptoms of hemochromatosis and its related complications.
2. The audience will learn about the aeromedical implications and flight considerations of patients with a history of hemochromatosis.

[248] DON'T BURST MY BUBBLE: BULLOUS EMPHYSEMA IN A COMMERCIAL SPACEFLIGHT PARTICIPANT

Bashir El-Khoury, Rebecca Mendelsohn

UTMB, Galveston, TX, United States

(Education - Case Study)

INTRODUCTION: This case report describes a 57-year-old man from the United States with a past medical history significant for bilateral, moderately severe bullous emphysema complicated by a history of spontaneous right sided pneumothorax who underwent medical screening prior to training for a 10-day mission on the International Space Station (ISS). **BACKGROUND:** Bullous emphysema is a type of chronic lung disease that is characterized by air cysts exceeding 1 cm in diameter. It is characterized by destruction of the lung parenchyma resulting in limitations in airflow from loss of lung architecture and enlargement of the alveolar space. Bullous emphysema is a subset of chronic obstructive pulmonary disease (COPD), which is currently the third leading cause of death in the United States and fourth leading cause of death worldwide. **CASE PRESENTATION:** This spaceflight participant was seen for medical

screening and optimization prior to commercial space travel. He was a slender man with a history of bullous emphysema and spontaneous pneumothorax in 1999 treated with thoracoscopy, lung biopsy, and talc pleurodesis. He admitted to smoking 1.5-2 packs per day for about 17 years, but quit 40 years ago. He denied any history of difficulties with commercial air travel and had no limitations with regular exercise. His chest radiograph demonstrated bilateral mild hyperinflation with flattening of the diaphragms, symmetrical apical pleural thickening, and blunting of the left costophrenic angle. High resolution computed tomography demonstrated multiple thin-walled cystic air spaces. Pulmonary function tests demonstrated moderately severe obstruction with significant reversibility. Additional testing was performed to assess his ability to tolerate launch, landing, and any possible changes in air pressure during the spaceflight. **DISCUSSION:** This case report, initially published by Jennings et al. in *Aviation, Space, and Environmental Medicine* in May 2006, describes a relatively rarely encountered condition in the spaceflight community, but one that has implications for medical clearance in the prospective spaceflight participant. Despite the presence of known intrinsic pulmonary disease, this spaceflight participant was able to be medically optimized prior to spaceflight by utilizing preflight testing to inform aeromedical risk.

Learning Objectives

1. Understand the presentation, diagnosis, treatment and complications of bullous emphysema in the aviator or spaceflight participant.
2. Understand how to assess aeromedical risk in the spaceflight participant with bullous emphysema and determine the potential implications of the condition on spaceflight.

[249] HIGH-G PILOT WITH INCIDENTAL DISCOVERY OF ARTERIOVENOUS MALFORMATION: A CASE STUDY

Noel Colls, Matthew Hoyt

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case describes an experienced pilot flying in a high-G platform with an incidentally discovered arteriovenous malformation (AVM). **BACKGROUND:** Intracranial surgery is often incompatible with high-performance aircraft operation. Intravascular embolization and stenting prevented disruption of the blood-brain barrier, allowed for use of the Aeromedical Consult Service Medical Risk Assessment & Airworthiness Matrix algorithm, and resulted in a categorical waiver and skill preservation of an experienced pilot. **CASE PRESENTATION:** Subject presented to clinic with slight left ear muffled hearing and Valsalva difficulty and treated for an ear infection; however, it was refractory to treatment. Subject was referred to Otolaryngology for possible conductive hearing loss. Thin-slice temporal bone computed tomography was normal. Magnetic resonance imaging had an incidental finding of a 2.5x1.5-cm Spetzler-Martin grade I AVM involving the anterior right frontal lobe without hemorrhage. Neurosurgery recommended Onyx™ endovascular embolization for a high likelihood of AVM cure and nearly zero postoperative seizure risk. Subject embolized twice; an iatrogenic right internal carotid artery dissection from the first embolization resulted in intravascular stenting. Subject tolerated the procedures well without further symptoms from initial diagnosis or treatment. **DISCUSSION:** Assessment by the subject's operational command found no limitations or flight safety concerns. The Aeromedical Consult Service focused on stressors applied to the carotid stent in high-G exposure and concomitant traction/rotation as well as the potential for seizure activity. Follow-up arteriogram showed incomplete obliteration of the AVM. Subject was recommended for a waiver restricted to multiplace, non-high-performance, non-ejection-seat aircraft, annual Neurology and Neurosurgery consultation, and repeat imaging to assess stability. Subject remained asymptomatic without signs of epileptiform activity, stent damage, or AVM recurrence. Subject's ejection seat restriction was removed. This exemplifies balancing risk mitigation with preservation of a combat pilot. The airworthiness matrix is an easy-to-use risk management tool for algorithmic discussion

of condition recurrence compared to outcome severity. Additional risk can be reduced by flight characteristic alteration, requiring a co-pilot, and ejection seat restrictions until subsequent evaluations demonstrate condition stability.

Learning Objectives

1. List additional diagnoses to consider when presented with a common complaint that is refractory to initial treatment.
2. Describe how to apply the Aeromedical Consult Service Medical Risk Assessment & Airworthiness Matrix to help guide a risk mitigation discussion.
3. Identify possible endovascular treatment modalities when dealing with a potentially career-ending intracranial pathology.

[250] MEDICAL CLEARANCE OF A MEDICALLY COMPLEX COMMERCIAL SPACEFLIGHT PARTICIPANT WITH CARDIAC, PULMONARY, ENDOCRINE, AND MUSCULOSKELETAL CONDITIONS

Karen Ong¹, Craig Kutz¹, Ed Powers², Michael Harrison³, Serena Auñon-Chancellor¹

¹UTMB, Galveston, TX, United States; ²Houston Methodist, Houston, TX, United States; ³Mayo Clinic, Jacksonville, FL, United States

(Education - Case Study)

INTRODUCTION: With advancements in commercial spaceflight, individuals of older age and with complex medical conditions are interested in participating in spaceflight. However, the physiological and functional effects of having multiple potentially interacting medical conditions in spaceflight is still not well understood, including the long-term effects of previous COVID-19 infection. This case report describes an older individual with multiple systemic health conditions (previously considered disqualifying) who subsequently was cleared for and successfully participated in a commercial spaceflight. **CASE PRESENTATION:** 65-80M commercial spaceflight participant with an extensive medical history including well-controlled cardiovascular (CAD, cardiac arrhythmia, HTN, HLD), pulmonary (previously mild COVID-19 infection, COPD), endocrine (hypothyroidism), and musculoskeletal (lumbar stenosis and rotator cuff injury) conditions along with mild hearing impairment. To our knowledge, the patient is the first commercial spaceflight participant known to have flown after COVID-19 infection (mild-to-moderate symptoms that self-resolved without hospitalization or medical interventions in the setting of mild COPD and pulmonary nodule). Additionally, the individual had previously had a positive stress test but subsequent unremarkable cardiac catheterization, resulting in medical management of his coronary artery disease. He also had a history of asymptomatic low-burden atrial ectopy without ventricular arrhythmia. The patient demonstrated sufficient function for spaceflight conditions and potential emergency operations despite mild hearing impairment and currently asymptomatic musculoskeletal conditions including a rotator cuff injury (status post-surgery) and asymptomatic spinal stenosis. **DISCUSSION:** Despite these multiple disqualifying health conditions, the patient's well-characterized and well-controlled conditions were deemed to pose an acceptable risk in the context of the patient's overall health and function. The patient was approved for commercial spaceflight and subsequently had a successful and enjoyable mission during which he continued his multiple regular oral medications without incident. In summary, individuals with a complex medical history including past mild COVID-19 infection may be able to safely undergo spaceflight if these medical conditions are thoroughly investigated and well-controlled in an individual with adequate physical function.

Learning Objectives

1. Understand the potential risks of common medical conditions for spaceflight.
2. Discuss the possible interactions of multiple medical conditions for spaceflight.
3. Better understand risk mitigation of common medical conditions in spaceflight.

[251] THE MARATHONER CONUNDRUM: COMPLETE CORONARY ARTERY OCCLUSION WITHOUT ISCHEMIA

Brit Geisler, Salvatore Bertucci

U.S. Army, Fort Rucker, AL, United States

(Education - Case Study)

INTRODUCTION: Heart disease is the leading cause of death in the United States and the leading cause of permanent flight duty suspensions. Flight surgeons need to be aware of the screening and treatment pathway, but many are not straight forward. Asymptomatic complete right coronary artery (RCA) occlusion in a high functioning aviator without any evidence of ischemia is a downright conundrum. **BACKGROUND:** Heart disease is the leading cause of death in the United States with coronary artery disease (CAD) at the top. Slowly progressing occlusion in CAD can foster development of collateral blood flow, but the prognosis of those patients is controversial. Studies suggest that having collateral blood flow with maintenance of heart function have lower overall risk of mortality, even with complete occlusion. They also could have better outcomes if they were to have an ischemic event. It has also been established that exercise improves coronary collateral growth. **CASE PRESENTATION:** A 51 years old male presents with an incidental ultrasound finding of a non-occlusive carotid plaque. He underwent an extensive workup that found complete occlusion of the RCA with collateral blood flow. Rest of the work up were normal. He is a non-smoker, non-drinker, very active with only medical problem is presumed familial hyperlipidemia. Repeat nuclear perfusion and angiography after 18 months showed preservation of heart function and no evidence of ischemia. He excelled his Army Combat Fitness Test, hiked Pikes Peak and continues to run marathons without symptoms. **DISCUSSION:** CAD is a common issue in the aviation community. An aviator with total occlusion of RCA without any evidence of ischemia, wall dysfunction, or abnormalities over an 18 month period presents a conundrum. Although not indicated, successful angioplasty could make him eligible for a waiver. He is extremely high functioning with regular high intensity exercise, has maximized his lipid management, and still remains symptom free. Studies support that his lifestyle is protective and he has a better prognosis than most other aviators. The conundrum is to fly or not to fly.

Learning Objectives

1. The audience will learn about the causes and symptoms of Coronary Artery Disease.
2. The audience will learn about the aeromedical implications and flight considerations of patients with Coronary Artery Disease.
3. The audience will learn about coronary collateral circulation growth and prognosis.

Wednesday, 05/24/2023

8:30 AM

Napoleon Ballroom D1-D2

[S-48]: SLIDES: OPERATIONAL ISSUES IN FATIGUE MANAGEMENT

Chair: Tom Nesthus

[252] THE IMPACT OF FATIGUE ON THREAT AND ERROR MANAGEMENT PERFORMANCE DURING LINE OPERATIONAL SAFETY AUDIT (LOSA) OBSERVATIONS

Daniel Wyman, Stephen Powell

Synensys, LLC, Peachtree City, GA, United States

(Education - Program/Process Review)

BACKGROUND: The Line Operations Safety Audit (LOSA) is a proactive safety assessment developed by the FAA and implemented across commercial and military aviation to improve safety and enhance performance. During normal operations, peer-to-peer observations are conducted using the Threat and Error Management (TEM) framework to collect and analyze data for trends and opportunities for improvement.

In 2018, USAF Air Mobility Command began collecting crew fatigue data during LOSA observations to better understand the state of fatigue across different aircraft/aircrew. Over 2400 crew members voluntarily completed fatigue surveys during LOSA flights. This presentation provides the initial analysis of the potential impact of aircrew fatigue on the management and mismanagement of Threats, Errors, and Undesired Aircraft States (UAS) during crew operations. **OVERVIEW:** The LOSA fatigue survey used was adapted from the Samn-Perelli and Karolinska Sleepiness Scales. The survey was anonymous and crew members were asked by the LOSA observer to complete the survey prior to the top of descent. The response rate was 91%. Our fatigue data analysis to determine TEM performance differences initially focused on cockpit crews due to the similarity of duties across aircraft type for comparison purpose. A total of 552 sorties were included in the analysis. Threats, Errors, and UASs were coded as *managed or mismanaged* by the LOSA observer and the most significant performance differences between fatigued and non-fatigued cockpit crews were identified. Our analysis showed that fatigued crews mismanaged more threats in only 3 of the 13 threat categories but mismanaged more errors in 11 of 14 error categories and significant differences were noted in key UAS categories. Additionally, during the C-40 Cockpit Crew LOSA in 2019, it was determined that 72% of observed UASs included a fatigue contributing factor. **DISCUSSION:** While most crew members are aware of the negative performance effects of fatigue, we may not be aware of how fatigue directly impacts TEM performance that is critical to maintaining safe flight operations. Our data suggests that fatigue most negatively impacts pilot error management performance and some critical UAS categories. Future LOSA data collection will continue to include fatigue surveys, Aviation Operational Risk Management fatigue scoring data, and other fatigue-related narrative data to develop actionable information to optimize TEM performance.

Learning Objectives

1. The audience will learn about the association of fatigue and the management/mismanagement of Threats, Errors, and Undesired Aircraft States as noted by observers during the Line Operational Safety Audit (LOSA) process.
2. The audience will learn to identify key categories of Threats, Errors and Undesired Aircraft States that were mismanaged by fatigued cockpit aircrew during LOSA observations.

[253] SOFTWARE ASSISTED FATIGUE AVOIDANCE INITIATIVE IN INDIAN NAVAL AVIATORS

Ranjan Sarkar, SS Mohapatra

Institute of Aerospace Medicine, Indian Air Force, Bengaluru, India

(Original Research)

INTRODUCTION: Aircrew fatigue is an omnipresent threat in Naval Aviation, especially in settings of onboard operations. Presently there are no objective assessment of fatigue in Indian Naval aviators and the assessment is based on following of laid down work/rest schedules. Fatigue Avoidance Scheduling Tool (FAST®) is a patented computer application derived from the physiological model validated by the US DoD. Wrist based devices are also used widely to keep a schedule of work and rest. This study was an attempt to assess the employability of these software-based assessment independently or in combination and measurement of their diagnostic accuracy in detection of fatigue in Indian Naval Aircrew. **MATERIAL & METHODS:** A total of 51 Indian Naval aircrew wore a wrist based actigraphy device for recording of work-rest/sleep data. The study was carried out in three different naval air stations and one ship (aircraft carrier) after receiving appropriate administrative and ethical clearance. Data was fed into a computer running FAST®. The 'measures of diagnostic accuracy' namely sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), likelihood ratio positive (LR +ve), likelihood ratio negative (LR -ve) and Youden's Index were determined using SPSS. **RESULTS:** The diagnostic measures calculated sensitivity

(68.4%), specificity (92.8%), positive predictive value (68.4%), negative predictive value (92.8%), likelihood ratio positive (9.5), likelihood ratio negative (0.34) and Youden's Index (0.61). With actigraphy integrated FAST® these values were: sensitivity (84.2%), specificity (96.4%), positive predictive value (94.2%), negative predictive value (94.4%), likelihood ratio positive (23.5), likelihood ratio negative (0.16) and Youden's Index (0.80). **DISCUSSION:** The increase in sensitivity (from 68.4% to 84.2%), specificity (from 92.8% to 96.4%), positive predictive value (from 68.4% to 94.2%), negative predictive value (92.8% to 94.4%), likelihood ratio positive (9.5 to 23.5) and Youden's Index (0.61 to 0.80) indicated that actigraphy integrated FAST® is a better screening tool in comparison to the independently employed FAST® in IN aircrew. We have recommended Employing actigraphy integrated FAST as screening and guiding tool during selected mission specific operational flying after necessary clearances

Learning Objectives

1. The findings of the study will lead to better understanding of operational fatigue especially in Carrier operations.
2. Scientifically validated Actigraphy devices could become standard issue supply for Indian Naval Aircrew.
3. It will lend objectivity to fatigue assessment in Indian Military aircrew and will lead to better crew scheduling.

[254] FOCUS GROUP STUDY OF US PILOTS ON FATIGUE IN SHORT-HAUL FLIGHT OPERATIONS

Cassie Hilditch¹, Kevin Gregory², Lucia Arsintescu¹, Nicholas Bathurst², Thomas Nesthus³, Hannah Baumgartner³, Amanda Lamp⁴, Laura Barger⁵, Erin Flynn-Evans²

¹San Jose State University, Moffett Field, CA, United States; ²NASA, Moffett Field, CA, United States; ³FAA, Oklahoma City, OK, United States; ⁴Washington State University, Spokane, WA, United States; ⁵Brigham & Women's Hospital, Boston, MA, United States

(Original Research)

INTRODUCTION: There are few studies investigating the impact of fatigue in short-haul flight operations conducted under United States (US) Federal Aviation Regulations (FAR) Part 117 flight and duty limitations and rest requirements. In order to understand the fatigue factors unique to short-haul operations, we conducted a series of focus groups across four major commercial passenger airlines in the US. The outcomes of this study were intended to inform the scope of a larger study of fatigue in short-haul operations. **METHODS:** Ninety short-haul pilots were recruited through emails distributed by airline safety teams and labor representatives. Fourteen focus groups were conducted via an online conferencing platform in which participants were asked to identify, specific to short-haul: a) schedules and operations that lead to elevated fatigue; b) schedules and operations that are not fatiguing, and c) important fatigue factors to study. Data were collected anonymously and coded using conventional qualitative content analysis, with axial coding and summative analysis used to identify main themes and over-arching categories. **RESULTS:** Participants had an average of 12,348 (6,483) lifetime flying hours with 71 (14.5) hours of monthly flying. Forty-six percent of participants were captains. The six fatigue factor categories identified were: circadian disruption (e.g., circadian switches, redevies), high workload (e.g., hassle factors, number of flights per duty), inadequate rest opportunity (e.g., minimum rest layovers, quality of rest facilities), schedule changes (e.g., unpredictability), regulation and policy issues (e.g., scheduling up to FAR 117 limits), and long sits (e.g., long wait times between flights). **DISCUSSION:** A field study informed by these results and designed to investigate the prevalence and impact of these factors in US short-haul operations is currently underway.

Learning Objectives

1. The participant will be able to describe the most common fatigue factors experienced by US short-haul pilots.
2. The audience will learn about current and future research agendas to help quantify and mitigate fatigue in short-haul operations.

[255] FATIGUE OPTIMIZATION DURING UNIVERSITY HELICOPTER PILOT TRAINING

Krisztina Szabó, Botond Szűcs

PharmaFlight Aeromedical Center, Debrecen, Hungary

(Original Research)

INTRODUCTION: Fatigue risk management plays a paramount role in optimizing everyday performance. Our aim was to evaluate the applicability of a fatigue risk management measuring and optimizing program during SWAT helicopter pilot training at a local university. Measurements included heart rate variability tests for peripheral nervous system activation, sleep data monitoring, cardiovascular risk factor monitoring. Intervention was changes in diet, physical activity and changing simulator training load according to the changes in individual data. **METHODS:** A total of 12 helicopter pilots (all males, age: 30.47 ± 5.39 years) participated in a 36-month program. We measured cardiovascular risk factors: blood pressure, pulse, augmentation index (AIX), pulse wave velocity (PWV), diastolic area index (DAI). Changes in autonomic regulation were evaluated by using heart rate variability (HRV). R-R intervals were measured for 6 minutes in a supine position. Parameters used: minimal pulse (p.min), average pulse (p.avg), maximal pulse (p.max), maximum-minimum pulse difference (p.max-p.min). Long-term continuous RR intervals (stda), standard deviation of instantaneous beat-to-beat variability (stdb), the number of pairs of adjacent NN intervals differing by more than 50 ms divided by the total number of all NN intervals (pNN50). Spectral analysis provided the low-frequency/high-frequency ratio (LF/HF). Sleep assessment included the measurement of sleep quantity, heart rate, breaths per minute, snoring. **RESULTS:** Systolic (133.38 ± 22.15 vs. 126.48 ± 20.22 mmHg) and diastolic blood pressure (76.95 ± 14.37 vs. 75.4 ± 12.7 mmHg) showed a reduction tendency. Pulse decreased (76.95 ± 14.37 vs. 72.53 ± 13.65 bpm). AIX showed slight improvement ($-33.54 \pm 5.59\%$ vs. $-31.93 \pm 3.79\%$); PWV data showed minimal change (7.74 ± 2.13 vs. 7.4 ± 2.73 m/s); DAI showed moderate improvement (49.32 ± 6.81 vs. 51.1 ± 7.01 m/s). HRV showed decreased p.max-p.min difference (18.78 ± 9.2 bpm vs. 15.5 ± 9.01 bpm), normalized dynamics (stda: (stda: 44.56 ± 35.97 vs. 69.63 ± 33.5 ; stdb: 30.88 ± 41.5 vs. 32.72 ± 35.84), slight sympathetic overload (pNN50: 7.33 ± 6.76 vs. 11.17 ± 5.24 , LF/HF: 169.52 ± 208.83 vs. 252.01 ± 351.16) during the program. Sleep quality showed undulating results in accordance with training load. **DISCUSSION:** Individualized intervention protocols, normalizing circadian rhythms and changes in simulator training load made it possible to shorten the university training from 36 months to 18 months.

Learning Objectives

1. The audience will learn about the close connection between autonomic nervous system and cardiovascular parameters.
2. The participants will understand how important it is to monitor even healthy young adults to predict their possible future risks for certain diseases.

[256] EYE TRACKING AS A FATIGUE SENSOR

Daniela Algranati¹, Idan Nakdimon¹, Gal Sapir², Anna Morozov³, Boaz Yariv³, Oded Ben-Ari¹

¹Israeli Air Force, Ramat Gan, Israel; ²Israeli Defense Forces, Ramat Gan, Israel; ³Eyeviation Ltd, Herzelyia, Israel

(Original Research)

INTRODUCTION: Fatigue is a significant consideration in flight safety. Therefore, the development of a sensor that will objectively detect and quantify the level of fatigue is of the essence. Sleep deprivation was found to extend the duration of eye fixations in the literature. The aim of this study was to analyze eye movements under fatigue in the Israeli Air Force (IAF). **METHODS:** IAF physiological qualification syllabus mandates a "Dead Tired" workshop, in which aircrew are exposed to sleep deprivation in a controlled manner. We analyzed the number and duration of fixations, the number and velocity of saccades, and pupil diameter. **RESULTS:** An eye tracking device was used to monitor 37 trainees (21 pilots,

11 navigators, and 5 unmanned aerial vehicle operators) during these workshops between November 2020 and March 2021. Duration of fixations, and the number of both fixations and saccades were found to be significantly higher following sleep deprivation. However, fatigue did not have a significant effect on either the velocity of saccades or pupil diameter. Unmanned Aerial Vehicle operators were found to be significantly resilient to sleep deprivation compared with pilots. **DISCUSSION:** Based on our preliminary results, we believe that eye tracking shows good potential to be used as a fatigue sensor. Although UAV operators was small group, their eye tracking metrics were less influenced by sleep deprivation.

Learning Objectives

1. Recognizing significant differences in eye tracking metrics during sleep deprivation.
2. The necessity of developing a fatigue Go / NoGo switch.

[257] HUMAN FACTORS CONSIDERATIONS TO MITIGATE FATIGUE EFFECTS IN SPACEFLIGHT OPERATIONAL PERFORMANCE

Erin Flynn-Evans

NASA Ames Research Center, Moffett Field, CA, United States

(Education - Tutorial/Review)

INTRODUCTION: Fatigue arising from sleep loss and circadian misalignment is a threat to successful human performance during spaceflight missions. Combatting fatigue during spaceflight operations requires a multi-factorial approach including vehicle design that facilitates sleep, schedules that maintain circadian entrainment, and countermeasures to minimize the impact of fatigue when it does occur. **TOPIC:** Human factors must be considered at every phase of a mission. The habitable volume of a space vehicle must allow crewmembers to achieve adequate sleep. This means that the vehicle must be designed so that the sleep environment achieves a comfortable sleeping temperature, with adequate airflow, and a quiet environment, free from intrusive background noise. The sleep environment must also include enough volume to allow for movement during sleep, potentially in multiple gravity environments, with private sleep accommodations for long-duration missions. The lighting in the vehicle must be sufficient to maintain circadian entrainment, while minimizing light pollution during the sleep episode. These design elements must be paired with other human factors considerations, including maintenance of a regularly timed schedule to maintain circadian entrainment. Fatigue countermeasures, such as lighting changes and increased cross-checking, should be available when crewmembers experience insufficient sleep or when sleep shifts are required. **APPLICATION:** Human factors are key to mitigating fatigue during spaceflight operations and should be incorporated into every phase of a mission, from vehicle design and conceptualization to mission planning and execution.

Learning Objectives

1. The participant will learn how human factors can mitigate fatigue when considered during the mission design phase.
2. The participant will learn how human factors can mitigate fatigue when considered during the implementation phase.
3. The participant will learn how human factors can mitigate fatigue when considered during the execution phase.

Wednesday, 05/24/2023

Napoleon C3

8:30 AM

[S-49]: PANEL: CERVICAL SPINE INTERVERTEBRAL DISC HERNIATION ON BOARD THE INTERNATIONAL SPACE STATION: DIAGNOSIS, TREATMENT AND OPERATIONAL MISSION IMPACTS

Chair: Richard Scheuring

Co-Chair: Rainer Effenhauser

PANEL OVERVIEW: INTRODUCTION: The authors describe the diagnosis, acute treatment, and rehabilitation of a mission impacting musculoskeletal medical condition in an astronaut during long-duration space flight on board the International Space Station. **BACKGROUND:** Rarely does a medical condition present in astronauts during the on-orbit phase of a space mission that has direct impact on crew health and mission objectives. During the record setting, long-duration mission of a U.S. astronaut, the team of NASA flight surgeons, astronaut strength conditions and rehabilitation experts along with outside consultants in neuro- and orthopedic spine surgery were presented with a case of acute onset cervical spine pain. The condition progressed in severity ultimately forcing the mission planners to reschedule an extravehicular activity (EVA), or spacewalk, modify the existing on orbit exercise prescription, and consider factors for an unscheduled return to Earth. There is no precedent for this type of musculoskeletal condition occurring in space prior to this case. The medical team had to develop a rehabilitation program on the ISS and consider alternatives to mission continuation in the event the individual did not respond to treatment. **CASEPRESENTATION:** A previously healthy US astronaut developed acute cervical spine pain during his 12-month mission on board the International Space Station (ISS). Details regarding the medical condition and treatment, rehabilitation plan, associated operational impacts, and spinal pathophysiology will be presented during this panel. **DISCUSSION:** Human space flight poses unique challenges to the diagnosis, treatment and monitoring of medical conditions. Flight surgeons rely on telemedicine for patient care, and the microgravity environment presents unknown physiological and anatomical changes to the human spine. A musculoskeletal rehabilitation treatment program was required to treat this medical condition, which prior to this mission, had never existed. Lastly, impacts to the mission objectives need to be considered.

[258] CERVICAL SPINE INTERVERTEBRAL DISC HERNIATION ON BOARD THE INTERNATIONAL SPACE STATION: PANEL OVERVIEW

Richard Scheuring¹, Rainer Effenhauser¹, Danielle Anderson², Paul Holman³, Melvin Helgeson⁴, Mark Vande Hei⁵
¹NASA JSC, Houston, TX, United States; ²U.S. Air Force, San Antonio, TX, United States; ³Houston Methodist Hospital, Houston, TX, United States; ⁴Walter Reed National Medical Center, Bethesda, MD, United States; ⁵NASA, Houston, TX, United States

(Education - Case Study)

INTRODUCTION: The authors describe the diagnosis, acute treatment, and rehabilitation of a mission impacting musculoskeletal medical condition in an astronaut during long-duration space flight on board the International Space Station. **BACKGROUND:** Rarely does a medical condition present in astronauts during the on-orbit phase of a space mission that has direct impact on crew health and mission objectives. During a long-duration mission of a U.S. astronaut, the team of NASA flight surgeons, astronaut strength, conditioning and rehabilitation experts along with outside consultants in neuro- and orthopedic spine surgery were presented with a case of acute onset cervical spine pain. The condition progressed in severity ultimately forcing the mission planners to reschedule an extravehicular activity (EVA), or spacewalk, modify the existing on-orbit exercise prescription, and consider factors for an unscheduled return to Earth. There is no precedent for this type of musculoskeletal condition occurring in space prior to this case. The medical team had to develop a rehabilitation program on the ISS and consider alternatives to mission continuation in the event the individual did not respond to treatment. **CASE PRESENTATION:** A previously healthy U.S. astronaut developed acute cervical spine pain during his 12-month mission on board the International Space Station (ISS). Details regarding the medical condition and treatment, rehabilitation plan, associated operational impacts, and spinal pathophysiology will be presented during this panel. **DISCUSSION:** Human space flight poses unique challenges to the diagnosis, treatment and monitoring of medical conditions. Flight surgeons rely on telemedicine for patient care, and the microgravity environment presents unknown physiological and anatomical changes to the human spine. A musculoskeletal rehabilitation treatment program was required

to treat this medical condition, which prior to this mission, had never existed. Lastly, impacts to the mission objectives need to be considered.

Learning Objectives

1. The audience will understand how telemedicine applied to diagnosing and treatment spinal disorders in space is accomplished.
2. The learner will become familiar with how a rehabilitation program for spinal musculoskeletal disorders in space is developed and executed.

[259] CERVICAL SPINE INTERVERTEBRAL DISC HERNIATION ON BOARD THE INTERNATIONAL SPACE STATION: DIAGNOSIS AND TREATMENT

Richard Scheuring¹, Rainer Effenhauser¹, Paul Holman², Melvin Helgeson³, Danielle Anderson⁴
¹NASA JSC, Houston, TX, United States; ²Houston Methodist, Houston, TX, United States; ³Walter Reed National Medical Center, Bethesda, MD, United States; ⁴U.S. Air Force, Houston, TX, United States

(Education - Case Study)

INTRODUCTION: A previously healthy, 55-year old male astronaut, with prior military and spaceflight experience, developed non-specific cervical spine pain approximately four months into his 12 month mission. **BACKGROUND:** Non-specific, limited musculoskeletal spine pain in astronauts in microgravity have been acknowledged during the six decades of human spaceflight. More recently, spinal changes have been studied and documented with pre- and post-flight imaging and on orbit stature measurements. Clinically, flight surgeons routinely observe mild, transient low back pain upon initial introduction of microgravity exposure in their crew members. However, standard screening assessments of spine integrity have not been routinely performed unless clinically indicated. Therefore, flight surgeons have had little insight to what underlying spine pathology may be brought into spaceflight. **CASE PRESENTATION:** The exact mechanism of injury in this astronaut was not clearly evident from his history. Despite conservative management, he subsequently developed an acute left sided C7 cervical radiculopathy 3-4 weeks after initial presentation of pain. His symptoms primarily consisted of radiating arm pain and numbness in a C7 distribution in addition to left sided triceps weakness noted during exercise. He did not have any changes in fine motor skills or evidence of myelopathy, although gait analysis was obviously limited. **DISCUSSION:** Despite the relatively permanent spine traction state in microgravity and conservative treatment measures, the individual developed unilateral C7 sensori-motor radiculopathy attributed to a C6-7 herniated nucleus pulposus. The crew member was removed from a scheduled EVA and began a treatment program on ISS to relieve his symptoms and return him to exercise. Upon consultation with experts in neurosurgery and orthopedic spine surgery assisted in the diagnosis, given the constraints of telemedicine during space flight, and guided conservative therapeutics regimen. Serial ultrasound imaging was conducted to evaluate the suspected levels in the cervical spine and aid in the differential diagnosis. The on orbit exercise prescription was modified in consultation with the astronaut strength, conditioning and rehabilitation (ASCR) team. Approximately 8-10 weeks after his initial presentation his symptoms improved to the point he was able to resume his full exercise routine and ultimately completed his entire mission duration.

Learning Objectives

1. The audience will become familiar with how ultrasound can be used for diagnostic imaging of the cervical spine on board the ISS.
2. The learner will gain insight into how the medical team during ISS Increment 65 diagnosed an acute cervical spine intervertebral disc herniation.
3. The participant will understand how microgravity impacts human spine anatomy and physiology.

[260] CERVICAL SPINE INTERVERTEBRAL DISC HERNIATION ON BOARD THE INTERNATIONAL SPACE STATION: OPERATIONAL MISSION IMPACTS

Rainer Effenhauser, Richard Scheuring
 NASA, Houston, TX, United States

(Education - Case Study)

INTRODUCTION: On-Orbit medical Issues have the potential to significantly impact spaceflight mission timelines and operations. This panel segment will discuss the Operational Impacts of a medical issue that occurred during spaceflight and the associated challenges and impacts to subsequent mission schedule and operations. These include things such as performing extravehicular activity (EVA, or spacewalks), exercise, and potential impacts to mission completion and subsequent landing operations. Familiarization with how daily crew activities developed by NASA Mission Operations planners are implemented and used by the astronauts during spaceflight will also be discussed. **CASE PRESENTATION:** A 55-year old male American astronaut developed cervical spine pain during his year-long mission on board the International Space Station (ISS). Symptom severity and confounding symptom presentation, ie paresthesia in the upper extremity, which may present during an EVA and represent acute decompression illness, prompted the mission medical team, mission managers and planners, along with medical specialists and the individual crew member to reconsider several mission objectives. **DISCUSSION:** At the end of this panel presentations, participants will be familiar with what a spaceflight mission schedule looks like, and how both minor and major medical issues have the potential to significantly impact mission timelines, operations, activities such as EVA, exercise, mission completion, and landing planning/operations.

Learning Objectives

1. The learner will become familiar with NASA spaceflight operations and how the medical operations team handles on orbit medical conditions that may have mission impact.
2. The audience will understand factors the flight surgeon considers during the on-orbit phase with impacts to performing mission objectives, such as EVA, exercise, contingency return planning and landing logistics.

[261] CERVICAL SPINE INTERVERTEBRAL DISC HERNIATION ON BOARD THE INTERNATIONAL SPACE STATION: ON-ORBIT MUSCULOSKELETAL REHABILITATION

Danielle Anderson¹, Richard Scheuring²

¹U.S. Air Force, Houston, TX, United States; ²NASA, Houston, TX, United States

(Education - Case Study)

INTRODUCTION: Cervical radiculopathy is a common condition seen within the civilian population. The incidence and prevalence are higher in operational environments with frequent exposures to g-forces and microgravity. The implications for mismanagement can be extreme and lead to severe disability and increased healthcare cost and utilization. In an environment that is 250 miles above earth, these implications are even more severe with operational impacts, minimal ability to medically evacuate and treat an individual, and an obligation to maintain the full health and safety of a crew member. Due to these demanding requirements and limited capabilities, innovative rehabilitation strategies are necessary to treat and mitigate long term impacts of the condition. **BACKGROUND:** ~10-20% of cervical radiculopathy cases require surgical intervention, leading to the majority of cases being managed conservatively by physicians and physical therapists. There is plenty of evidence to support conservative treatment through appropriate medication management, manual physical therapy intervention, and individually tailored exercises targeted to resolve symptoms of radicular pain, numbness/tingling, and cervical pain and dysfunction. Although well established in 1-g, this evidenced based approach to treat cervical radiculopathy is unknown in the microgravity environment. The evidence-based principles of physical therapy evaluation and treatment of cervical radiculopathy will be discussed and applied to a real case of an astronaut on-board the International Space Station. The rehabilitation program consisting of individually tailored cervical and thoracic mobility exercises and manually applied cervical traction and cervical rotation, performed by a seasoned Astronaut physician in microgravity, will all be discussed. **CONCLUSION:** Relying on advanced clinical decision making, evidenced based

principles of effective management in 1-g, and crew member ingenuity, effective treatment can be applied to fully resolve, maintain fitness, and mitigate long-term disability in microgravity, as demonstrated by a case of a 1-year long mission crew member on-board the International Space Station. Although the management of this case demonstrates a unique strategy to treatment, these cases are common in microgravity and will require imaging surveillance and pathological and physical characteristics assessment, to effectively prevent and treat future spine conditions in microgravity.

Learning Objectives

1. The learner will have a general overview of conservative evidenced based treatment strategies for cervical radiculopathy.
2. The learner will be able to discuss the clinical prediction rule for cervical radiculopathy and patients who will respond best to traction-based interventions.

[262] CERVICAL SPINE INTERVERTEBRAL DISC HERNIATION ON BOARD THE INTERNATIONAL SPACE STATION: SPINE PATHOPHYSIOLOGY

Melvin Helgeson¹, Paul Holman²

¹Walter Reed National Medical Center, Bethesda, MD, United States;

²Houston Methodist, Houston, TX, United States

(Education - Case Study)

INTRODUCTION: The spinal pathophysiology of long-duration space flight is not fully understood. We present a case discussion of spinal pathology in relation to a recent astronaut who developed cervical radiculopathy during flight. **BACKGROUND:** Throughout the history of human spaceflight, researchers have sought to better understand the significant impact on the musculoskeletal system and the spine. Several case reports exist within the literature describing the acute impact on spinal morphology and it is widely accepted that the spine elongates up to six centimeters when humans are exposed to the microgravity environment. While the spine anatomy changes, decreasing the normal sagittal alignment of kyphosis/lordosis, the spine also undergoes traction during flight. This traction and loss of loading across the intervertebral disk undoubtedly leads to changes within the microarchitecture of the disk space. There has been an increase in disk herniations, with up to 10% of US astronauts sustaining disk herniations post flight. There have not been any reports of disk herniations developing during space flight or any episodes of cervical/lumbar radiculopathy. **CASE PRESENTATION:** Without the ability to perform standard cervical spine imaging (MRI) on board the International Space Station, the assumption was this individual's signs and symptoms represented an acute disk herniation. Knowing traction occurs within the microgravity environment caused concern among the medical team members, and led to a conservative approach to activities, cancelling his scheduled EVA. The team could also not rule out spinal cord compression without available imaging. Proceeding cautiously with conservative management, his symptoms improved over the next 3 months, consistent with the natural history of cervical radiculopathy. His post-flight MRI obtained 24 hours after landing, eight months after the development of symptoms, revealed significant degenerative changes at the suspected level. **DISCUSSION:** The management of acute cervical radiculopathy is well accepted to be conservative initially in the absence of myelopathy. Conservative treatment was appropriate in this case, but the medical team was concerned about the possibility of spinal cord compression and the uniqueness of symptoms within a traction, microgravity environment. The pathophysiology of disk herniations within this environment needs to be better understood as we seek more frequent and longer duration flights.

Learning Objectives

1. The audience will become familiar with cervical spine anatomy as it relates to physical exam findings in the setting of acute radiculopathy.
2. The learner will be able to describe how conservative management of an acute cervical spine herniated disc in an austere environment can be diagnosed and treated.

3. The learner will understand the criteria for returning an individual with an acute cervical spine herniated disc from space.

Wednesday, 05/24/2023
Napoleon Ballroom A1-B3

8:30 AM

[S-50]: PANEL: TECHNICIAN PERSPECTIVE ON PHYSIOLOGICAL ADVANCEMENTS

Chair: Rachelle Lang

PANEL OVERVIEW: *The Aerospace Physiology career field fills a unique niche in supporting today's flying operations with its diverse experience and involvement in providing training, research, and operational support all over the world. From the establishment of the "Altitude Training Program" in 1942 during WWII, it has continued to advance in its mission of protecting aviators. Even to this day, the Aerospace Physiology Training Teams have continued to expand their extensive involvement and understanding parallel to the world-wide ever growing aircraft inventory. From standing up the newest Chamber Training Unit at Joint Base San Antonio-Lackland, to launching U-2 pilots to the edge of space, to providing G-induced Loss of Consciousness prevention training or assisting special operator parachutists; each member of this elite community actively contributes to numerous flying missions world-wide. In this panel we will discuss the Aerospace Physiology enlisted tier's impact on operations. These technicians are intertwined within day-to-day operational missions providing a bridge between Team Aerospace and operational communities. This panel provides unique insights into an operational support mission not frequently understood and in so doing elucidates key components critical to enhancing team aerospace's integration into the operational community. Panelists will discuss aspects learned in their day-to-day interactions, from running the only US Department of Defense centrifuge, by training pilots to stay conscious at 9 Gs, to challenges with equipment, use and procedures for U-2 missions and much more. These members hold a critical role as the gatekeepers to flight for every aviator and their last line of defense between life and death.*

[263] SUPPORTING ENLISTED FLYERS: LESSONS LEARNED FROM STARTING SOMETHING NEW

Christina Ingram

Joint Base San Antonio-Lackland, San Antonio, TX, United States

(Education - Program/Process Review)

BACKGROUND: The 344 Training Squadron at JBSA-Lackland is the newest chamber unit in the aerospace physiology inventory. It is the only chamber to directly support two enlisted pipelines, the Career Enlisted Aviator (CEAs) and Special Warfare training pipelines. This presentation will describe lessons learned in establishing chamber operations to include collaborations with the medical community. **OVERVIEW:** Hurricane Michael destroyed Tyndall AFB in 2018. Reevaluating the need for a second chamber unit in San Antonio, the altitude chamber was moved to JBSA-Lackland and was officially opened 15 June 2022. Starting chamber operations from a blank slate provided both struggles and opportunities. Additionally, the unique mission of this chamber enabled a new perspective on enlisted aircrew support. Supporting roughly 2,300 students a year provided unique insight into common concerns, complaints, and issues that affect the CEA community. Broken down by AFSC, this presentation will describe training and unique AFSC concerns as provided by cadre. **DISCUSSION:** This topic will provide current data to DCS and chamber reaction rates as an overview to JBSA-Lackland operations. Additionally, this presentation will describe common injury and medical complaints in Career Enlisted Aviators for each AFSC and developed holistic AFSC specific solutions.

Learning Objectives

1. The audience will learn the current data for DCS and chamber reaction rates for JBSA-Lackland.

2. The audience will learn about some of the common injuries/medical complaints experienced by CEAs (career enlisted aviators) for each AFSCs, and solutions to rectify.
3. The audience will learn about the problems encountered/lessons learned with standing up a new unit.

[264] THE ROLE OF AEROSPACE PHYSIOLOGY TRAINING TEAM (APTT) IN OPERATIONS SUPPORT

Luciano Cattaneo

Community College of the Air Force, Ramstein Air Base, Germany

(Education - Program/Process Review)

BACKGROUND: In October 2021, the Air Force re-aligned the Aerospace Physiology (AP) career field under Line of the Air Force (LAF). Said transition from Medical to line streamlined our reach to the operators we support. This presentation will highlight the key role of Aerospace Physiology Training Teams (APTTs) and some of the born challenges post migration. **OVERVIEW:** Effective physiological training of aircrew demands AP personnel have operational experience. This is achieved by exposing aerospace physiologists and technicians to the actual flying environment thus enhancing their credibility with their audience—we should have one foot firmly planted in science and one in operations. **DISCUSSION:** In order to prepare aircrew to anticipate, recognize, correct and survive a Physiologic Event (PE), its imperative APTTs possess the tools to relate to the daily challenges aviator's encounter. As we are now under the operations umbrella, APTTs solidify a bridge between Team Aerospace and the line. Said relationship promotes training opportunities and exposes medically based professionals to the operations world; one of the many advantages the LAF provides. A drawback, however, is that each APTT is faced with unique challenges within their respective squadron and base agencies. Uncertainty from aircrew on the services provided by the APTT and ambiguity in our relationship with the MDG regarding the role and responsibilities of the APTTs, have proven to be common pitfalls. **CONCLUSION:** Since transition, the enlisted tier has evolved to take on responsibilities traditionally reserved for officers. With our medical roots and operational experience APTTs are thriving whilst influencing aircrew, base agencies, and strengthening Team Aerospace worldwide. **RECOMMENDATIONS:** Continue to mold and develop AP personnel in aviation without losing our medical background while promoting flying on different platforms which will only emphasize our footprint in Aerospace Medicine.

Learning Objectives

1. The audience will learn about the roll of APTTs in the LAF.
2. Listeners will understand the advantages and challenges presented after Aerospace Physiology was aligned to the LAF.
3. This presentation will highlight the critical role of enlisted members in APTTs.

[265] AEROSPACE PHYSIOLOGY ACCELERATION TECHNICIAN/PROCESS REVIEW

Queneth Salazar

Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: The job of centrifuge technicians at Wright-Patterson AFB is to prepare aircrew for the physiological stressors of high-G flight. The airframes that we support are T-38, A-10, EA-18, F-15C/E, F-16, F-22, and F-35. The three standard syllabus courses we execute are the Primary, Advanced, and Non-Pipeline Acceleration Training courses. **OVERVIEW:** At Wright-Patterson AFB, we provide acceleration training to the fighter community. We instruct students on a proper G-straining technique to combat threats associated with fighter operations. We support war efforts by utilizing a 35-million-dollar centrifuge to expose aircrew to the high-G environment prior to their first flight in a high-G platform. The primary objective of centrifuge training is to train aircrew on a high-quality Anti-G Straining Maneuver (AGSM) and evaluate

their performance in a controlled environment. The technique consists of three major components which include a lower body muscle contraction, a respiratory component, and a relaxed upper body. Compared to the previous "hook" method, which included a tight breath hold, the newer approach stresses a calmer breath hold to enhance air management and reduce instances of G-induced loss of consciousness (GLOC). We also now emphasize a relaxed upper body to decrease fatigue levels and improve air management. During program execution, we have found Primary students typically require more time in the centrifuge (respins) to learn the proper technique when compared to Advanced pilots. Our respiration rates went from 49% in Primary students to 28% in Advanced students due to their previous experience in the centrifuge and time executing the AGSM in the aircraft. **DISCUSSION:** With Wright-Patterson AFB being the sole centrifuge owned by the Department of Defense, it is crucial for aircrew to receive high quality training during their time at Wright-Patterson. This allows aircrew to understand, apply, and improve their AGSM to ensure combat effectiveness. Lessons learned over the years have provided a refined approach to training that will help minimize GLOCs and pilot fatigue, providing a direct benefit to high-G aviators. The skillset of the technicians at the centrifuge is also utilized to provide training for international pilots from more than 20 countries worldwide. With more advances in aircraft technology, we must continue to adapt our training to enhance human performance and continue to defeat the threats associated with high-G flight.

Learning Objectives

1. The audience will learn about the Anti-G Straining Maneuver and the benefits of it.
2. The audience will learn how big of a difference the technique is from the "hook" to "relaxed breath hold."

[266] HIGH ALTITUDE AIRDROP MISSION SUPPORT

George Wild, Jeffrey Nelson

U.S. Air Force, Scott AFB, IL, United States

(Education - Program/Process Review)

BACKGROUND: Air Mobility Command (AMC) is pursuing an increased use of augmented minimum manned aircrews (Single Pilot and Load Master). Additionally, AMC has implemented go/no-go pill use to aircrew. Furthermore, the Air Force allows for single Jump Master operations. Specific entities within the DoD would like to have non-Aerospace Physiology (AP) technicians become trained in High Altitude Airdrop Mission Support (HAAMS). Aerospace Physiology (AP) HAAMS technicians are vital to be able to bridge the gap between United States Air Force (USAF) Aircrew and parachutist to reduce overall mission risk. The AP HAAMS personnel at JB Charleston are the best and most qualified personnel to perform the HAAMS mission. **OVERVIEW:** Expected increased ops tempo/duration, minimum manned crews, go/no-go pill implementation and potential decreased experience in the Aircrew and Parachutist community have the potential to widen the operational safety gap and increase the risk to achieve overall mission success. AP HAAMS technicians need to increase their presence and capacity to bridge the gap as demands increase. Air Mobility Command and JB Charleston have been authorized additional HAAMS manpower positions to double the overall unit manning to meet increased operational requirements and tempo. Additionally, updated HAAMS operational guidance via AFMAN 11-409 is routing for approval and will mirror Aircrew requirements. The additional manning positions are needed to support increased mission requirements and updated guidance to outline HAAMS 1H/13H upgrade training requirements. Additionally, further clarification is required on what other entities within the DoD should or can perform HAAMS duties on non-Air Force aircraft or involving non-Air Force personnel. **DISCUSSION:** What are the limitations to the human body with regards to time, fatigue, situational awareness, and cognitive limitations as it pertains to operational decision making in regard to risk reduction and management as we draft OPLANs to fight in INDOPACOM? Can the Air Force safely support single

pilot, single load master on an extended duty day, operating on go pills, dropping a US ARMY SOF team in INDOPACOM? Highly trained HAAMS personnel are critical to safe mission execution, are HAAMS personnel still operationally effective after a 48-hour transport in the back of a C-17?

Learning Objectives

1. Understand the potential for increased AMC ops tempo and increased parachutist ops within SOF.
2. Understand the potential for increased human error with decreased experience, decreased crew compliment and increased go/no-go pill usage.
3. Understand the safety role that AP HAAMS technicians provide to bridge the gap between Aircrew and Parachutist.

[267] U-2 PHYSIOLOGICAL SUPPORT TECHNICIANS – BETWEEN LIFE AND DEATH

Michael Heatherly, Jimmy Sayarath

U.S. Air Force, Beale AFB, CA, United States

(Education - Program/Process Review)

BACKGROUND: Since the first days of operating the U-2 in 1955, physiological support technicians have kept aircrew safe—from inspecting life support equipment to dressing and integrating pilots inside the cockpit of the aircraft. As time progressed, technology advanced, and equipment was upgraded but the Physiological Support Squadron is still conducting the same job with a lot of the same equipment from U-2 inception. Despite antiquated equipment and low manning, they keep the High-Altitude Intelligence, Surveillance, and Reconnaissance mission alive worldwide providing vital intel to Higher Headquarters and our allies. **OVERVIEW:** Physiological support technicians are an elite cadre of specially trained Aircrew Flight Equipment and Aerospace Physiology personnel. The Physiological Support Squadron houses the Air Force's only depot, maintenance, training, and utilization for space suits. These experts are responsible for sizing all pilots, maintaining the space suits and sub-assemblies, donning and doffing the pilot's space suit, and integrating the pilot into the aircraft every flight. They also maintain the personal egress and survival equipment used with the U-2 airframe. Although the aircraft and sensors have improved over the U-2's seventy-year life, the systems and technology protecting the human remain largely unchanged creating unique challenges. **DISCUSSION:** The men and women of the 9th Physiological Support Squadron adapt and overcome these obstacles through innovation, dedication, and the leveraging of relationships with the System Program Office, Original Equipment Manufacturers, and pilots. This panel will explore this unique mission set and what it takes to safely launch pilots to the edge of space every day despite the inherent challenges.

Learning Objectives

1. The audience will learn about the 9th Physiological Support Squadron and how they are accomplishing the mission given with outdated equipment.
2. The participants will be able to understand the skillsets our Airmen at the 9th Physiological Support Squadron gain while performing the duties.

Wednesday, 05/24/2023

Grand Ballroom A-B-C

10:30 AM

[S-51]: SLIDES: TO INFINITY AND BEYOND

Chair: Jaime Rivas-Harvey

[268] A COMPUTATIONAL MODEL OF MOTION SICKNESS DRIVEN BY SENSORY CONFLICT FROM SPATIAL ORIENTATION PERCEPTION

Aaron Allred, Torin Clark

University of Colorado-Boulder, Boulder, CO, United States

(Original Research)

INTRODUCTION: Most astronauts experience motion sickness upon transitioning to a microgravity environment from Earth and particularly upon returning to Earth following extended exposure to microgravity. To improve crew health and performance during future NASA exploration class missions, more effective countermeasures to motion sickness must be developed. However, effective motion sickness countermeasures are not always intuitive (e.g., in some instances, the addition of 'countermeasures' such as the addition of visual cues and various behavioral approaches may result in more motion sickness). In order to better predict motion sickness severity, a computational model of motion sickness is necessary. Previous motion sickness models have placed a decreased emphasis on the spatial orientation perception stage for the processing of sensory conflict to drive motion sickness and instead have relied on model predictions of motion sickness (commonly motion sickness incidence) alone to dictate model accuracy. **METHODS:** Our motion sickness severity model is driven by sensory conflict resulting from a perceptual model validated across several motion paradigms (i.e., the "observer model" for spatial orientation perception during passive motions). The downstream motion sickness dynamic pathways are based on Oman's heuristic model with modified parameters to achieve characteristic emetic responses across motion frequencies. To determine how the individual conflict components from the perception processing should be rectified and weighted for input into the motion sickness dynamics, weighting terms were fit via an optimization scheme using existing motion sickness data for passive motions as ground truth data. **RESULTS:** With passive motion over time as an input, the model produces predictions of motion sickness severity, dependent on specific sensory conflict signals from the observer model. Additionally, the model captures previously noted motion frequency dependencies, and the severity can be mapped to common reporting metrics, such as the Misery Scale (MISC). **DISCUSSION:** Following model predictions motion sickness, this cohesive model enables further development of countermeasures for motion sickness during passive motions. Furthermore, this model can produce motion sickness severity predictions from conflict arising from an altered or adapting sensorimotor state such as that experienced by astronauts adapting to gravity transitions.

Learning Objectives

1. Understand the role of individual sensory conflicts, from the Observer model, in contributing to motion sickness.
2. Explore how to optimize a computational model of motion sickness for various reporting scales.
3. Computationally predict motion sickness for arbitrary passive motions.

[269] ASTRONAUT TRAINING AND ANALYSIS OF SLEEP AND PERFORMANCE DURING THOR SPACE ANALOG SIMULATION

Marian Farfan, Diego L. Malpica
Colombian Air Force, Bogota, Colombia

(Original Research)

INTRODUCTION: Human exploration of space beyond Low-Earth Orbit will require crews to stay under isolated, confined, and extreme (ICE) environments with restricted resources and limited mission control support while maintaining optimal performance, being critical for mission safety and success. We aim to investigate the possible effects of sleep patterns, fatigue, and emotions on cognitive performance in five crewmembers on a six-day campaign for a Lunar mission as part of The Human Operation Research space analog. **METHODS:** Data collection began five days before launch and continued for six days in the space analog habitat. We ran daily psychomotor vigilance task (PVT) tests using NASA PVT+ on an iPad which objectively assessed reaction time and also gathered crewmember's self-reports of sleep-wake behaviors and fatigue. In addition, sleep and activity patterns were permanently monitored with wrist-worn actigraphy with scheduled nighttime sleep and

day-work hours (within-subject design). The Positive and Negative Affect Schedule (PANAS) scale was also used to assess emotions daily. **RESULTS:** Although the average individual sleep duration was 7.65 ± 0.8 h, there was substantial sleep deprivation during the second and primarily on the fourth day of the campaign, with significantly less accurate psychomotor vigilance on the same days. In the survey, subjects reported significantly worsening mood during the days of reduced sleep time on several affective domains. **DISCUSSION:** The results suggest that sleepiness, fatigue, and emotions affect the cognitive performance of crewmembers during a space analog mission. These findings underline the importance of managing the cumulative effects of sleep-deprived crews and enhancing coping strategies for positive adaptability to improve efficiency on critical tasks in isolated, confined, and extreme (ICE) environments.

Learning Objectives

1. The participant will understand the effects of negative affection on total sleep time, restless sleep, and reaction time in a Lunar analog simulation.
2. The audience will understand further how emotional factors may impact crewmembers' performance in a Lunar analog simulation.

[270] USING MARKERLESS MOTION CAPTURE IMAGING FOR THE FUNCTIONAL ASSESSMENT OF ASTRONAUTS BEFORE, DURING AND AFTER SPACEFLIGHT

Douglas Hamilton

University of Calgary, Calgary, AB, Canada

(Original Research)

INTRODUCTION: Recent advancements in markerless motion capture and analysis technology along with the science of 'Clinical Biomechanics', clinicians can now measure and treat their patients with observations which are automated, accurate and objective compared to the previous methods of subjective observation and primitive measurement techniques such as goniometers. **METHODS:** Our motion lab utilizes an 8-camera "markerless" 3-dimensional motion capture system solution that can perform a whole-body examination in 15 – 30 minutes. The research team has adapted the Theia3D™ technology to employ lower cost high resolution cameras and a user interface for clinical medicine and occupational therapy environments to create a portable motion capture capability. This research was compliant with all appropriate ethics, privacy and security procedures and protocols. (i.e. Conjoint Health Research Ethics Board of the University of Calgary). **RESULTS:** This system now has a normative motion database which uses temporal and spectral autocorrelation to time align the total body motion and gait of 40 subjects. This system is unique in that it measures joint and limb range of motion and temporally tracks in 3-dimensions, the whole-body motions used by the participant to achieve these ranges. This study created the world's first normative waveform database for over 50 standard physiotherapy/kinematic motions commonly used for body motion analysis. **DISCUSSION:** Mulavara et al* performed seven functional tests to investigate the sensorimotor, cardiovascular, and neuromuscular adaptations to spaceflight. We are proposing to perform markerless image capture and analysis of functional testing pre/post spaceflight and on the ISS during treadmill, bicycle ergometer and ARED training. Over time, statistical tracking of an astronaut's career can be measured with reference against themselves or our normative data set. As our data set grows this normative waveform database is being expanded to include risk cohorts according to age, body habitus, gender, mechanism of injury, treatment, or pathology such as lower back injury. *Mulavara et al Psychological and Functional Alterations after Spaceflight and Bed Rest. Med. Sci. Sports Exerc., Vol. 50, No. 9, pp. 1961–1980, 2018.

Learning Objectives

1. The audience will learn how clinicians can now measure and treat their patients with observations of motion which are automated, accurate and objective compared to the previous methods of subjective observation and primitive measurement techniques such as goniometers.

2. The audience will learn how the research team created the world's first normative waveform database for over 50 standard physiotherapy/kinematic motions commonly used for body motion analysis.
3. The audience will learn how this motion capture technology can be used for the statistical tracking of an astronaut's motion over their career with reference against themselves or our normative data set.

[271] MEDICINE, MOON, AND MOTIVATING THE ARTEMIS GENERATION: ELEVEN TIPS FOR EFFECTIVELY ENGAGING AUDIENCES

Jason-Flor Sisante^{1,2}

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(Education - Tutorial/Review)

INTRODUCTION: The Artemis program heralds the new age of human space exploration. The technological vanguard and historic goals of Artemis offer an opportunity to boost interest in the STEM fields, particularly in aerospace medicine, across global audiences. This case study provides eleven tips garnered from a decade's worth of presentations about Artemis' component programs. These tips may be useful in engaging audiences as our return to the moon approaches. **TOPIC:** The ambitious Artemis program aims to send the first woman and the first person of color to the surface of the moon, establish a lunar outpost, and assemble an orbiting lunar space station. It is the foundation for future deep exploration missions. Thus, with the unique challenges of the program arousing the general public's interest in space exploration, aerospace medical professionals have a unique opportunity to leverage this excitement and spur interest in the biomedical sciences and other STEM fields. **APPLICATION:** To successfully engage a wide variety of audiences, aerospace professionals should: (1) highlight the unique intersection among aerospace engineering, medicine, isolated environments, and exploration; (2) leverage social media and mass media outlets; (3) show the inherent joy of the scientific endeavor through fun demonstrations; (4) create an atmosphere contradictory to the typical lecture; (5) collaborate with non-scientific experts and artists; (6) practice respectful, but ardent, debunking of conspiracy theories; (7) advertise the technological advancements developed from space agencies; (8) individually engage local and national STEM pipelines by speaking and volunteering at schools, colleges/universities, public libraries, and science fairs/competitions; (9) use virtual meeting spaces and movie production software to reach faraway audiences; (10) tactfully use humor to emphasize key points; and (11) distill their professional expertise into lay language. At the dawn of our lunar return, the aerospace medical community is in an exclusive position to address the public's interest in both the cosmos and the human body. Through inspiring, informative, and interesting outreach, aerospace medical professionals can influence the next cadre who will push the future phases of exploration and clinicians and scientists who will push medical knowledge.

Learning Objectives

1. The audience will learn how to enhance their public presentation skills.
2. The audience will learn how to uniquely advocate for STEM pipelines and engage these pipelines.

[272] INTEGRATED VIRTUAL REALITY VISUALIZATIONS AND INFORMATION DISPLAY TO UNDERSTAND UNCERTAINTY IN TRAINING FOR SPACEFLIGHT OPERATIONS

Savannah Buchner, Noah Abeson, Jennifer Wood, Hanspeter Schaub, Allison Anderson

University of Colorado-Boulder, Boulder, CO, United States

(Original Research)

INTRODUCTION: With the planned increase in on orbit operations, such as satellite service and repair, there is a need for easy-to-interpret displays for complex missions. Human operators will assist in tasking on-orbit activities and act as supervisors to autonomous systems, aiding

them in making decisions and executing actions. Humans will be separated both spatially and temporally from the spacecraft and will be required to process complex data. Operators will need to understand how small uncertainties in planned actions, such as a potential imperfect thruster burn or noisy sensor readings, can impact future states to make appropriate operational decisions. Thus, effective training is needed. Virtual reality can provide immersive, high fidelity, realistic simulations of the environment, but little work has been done in the realm of spaceflight operations and remote supervision. **METHODS:** We developed a simulation of a servicer satellite in proximity operations around a dead target satellite using Basilisk, a high-fidelity physics-based spacecraft simulation tool. Uncertainties are introduced through simulated imperfect thruster burns and noisy sensor readings. These uncertainties propagate and impact the future states of the satellites, leading to collision possibilities between the two simulated satellites. The simulation is visualized using Unity and an HTC Vive headset and controls to create an immersive visualization of proximity operations. Operators can see the states of satellites, actions with their associated uncertainties and impact on future states, and a host of other displayed information. **RESULTS:** Human factor approaches were used to identify appropriate choices of displays and visualization to convey information to the operator. The best practices from traditional 2D displays are combined with the immersive experience that VR provides to facilitate understanding of the environment, uncertainties, and their importance. Operators can change their viewpoint to better understand the relative orientations, drawing from immersive display benefits, as well as toggle on or off pieces of information designed with traditional display philosophies, as desired. **DISCUSSION:** We assess usability through user evaluations to evaluate the approaches taken and their effectiveness at conveying the information in an appropriate way to improve operators understanding on the environment and impacts of uncertainty in the operational environment.

Learning Objectives

1. The audience will learn about using virtual reality to train operators on the impact of uncertainties on spacecraft operations.
2. The audience will learn about integrating the human factors of virtual reality and traditional 2D aerospace display design.

[273] TO MARS AND BEYOND: PARKINSON'S DISEASE IN THE AGE OF COMMERCIAL SPACE TRAVEL

William Hoffman

Brooke Army Medical Center, San Antonio, TX, United States

(Education - Case Study)

INTRODUCTION: A theoretical case of a 61-year-old male with past medical history of medically managed Parkinson's Disease with mild tremor and bradykinesia, mild orthostatic hypotension and REM sleep behavior disorder who presents to the outpatient neurologic clinic for evaluation prior to commercial space travel at the direction of the commercial space company. **BACKGROUND:** Commercial space operations are expected to increase the pool of eligible space travelers, to include patients with chronic neurological disorders such as Parkinson's Disease. Commercial space companies are directing patients to their primary and specialty care physicians for medical optimization prior to space travel, but there is limited data to guide the management of certain neurological disorders in the space environment. Parkinson's Disease is among the most common neurodegenerative disorders with diverse manifestations potentially worsened in the space environment. We propose an approach for medical optimization of the commercial space traveler with Parkinson's Disease. **CASE PRESENTATION:** The patient underwent evaluation in the neurology clinic focused on (1) motor symptoms, (2) orthostatic hypotension, and (3) REM sleep behavior disorder with the space environment in mind. The presenter will also suggest other topics of counseling to include helping a patient select a medically appropriate mode of space travel, pre-travel preparation and safety planning. **DISCUSSION:** Commercial space travel is expected to increase the number of eligible travelers, to include patients with Parkinson's Disease. The current proposed case and

discussion are intended for the non-aerospace neurologist seeing patients wishing to participate in commercial space travel.

Learning Objectives

1. Identify medical-legal considerations for the neurologist caring for a patient wishing to participate in commercial space travel.
2. Describe three aeromedical considerations for commercial space travel in a patient with Parkinson's Disease.

Wednesday, 05/24/2023

10:30 AM

Grand Ballroom D-E

[S-52]: PANEL: FORTIFYING COMPREHENSIVE MEDICAL READINESS PROGRAM FOR FLIGHT SURGEONS

Chair: Anthony Waldroup

Co-Chairs: Jason Burchett, Douglas Files

PANEL OVERVIEW: Background: Flight medicine professionals often perform duties in sites outside their normal workplace. Military and civilian aerospace medicine providers prepare to work in alternate sites much of the time. Overview: This panel includes discussions of solid practices in performing those duties in a deployed setting. Additionally, the current panel and its sister panel renew U.S. Air Force flight surgeons' Comprehensive Medical Readiness Program (CMRP) requirements to make them as ready as possible to perform deployed duties. Discussion: Sessions in this panel will involve travel medicine, mass casualty response, in-flight physiologic emergency response and aeromedical evacuation of sick patients, along with other relevant topics. Participants update their knowledge and consider whether they can incorporate good practices from other bases in their next deployment.

[274] FORTIFYING PREVENTION AND TRAVEL MEDICINE

Cady Blasser, Douglas Files, Jason Burchett

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: Aerospace medicine providers support flying operations that affect the safety of populations supporting the flying mission. However, airfield operations are not always in the nation of origin, thus flight surgeons and the people they support need to be prepared to deploy worldwide. This discussion will encourage aerospace medicine professionals to maintain currency by participating in travel medicine briefings and administrative tasks. **OVERVIEW:** Regular responsibilities of flight surgeons include serving as the medical expert on travel health issues. This task is complicated by the wide variety of locations where airfield operations can occur. Medical travel guidelines are always changing. Emerging technology may also be involved. This program will prepare aeromedical professionals to participate in travel medicine briefings and clinical tasks such as the prevention of tropical diseases. **DISCUSSION:** Safety risks to aircrew have increased with global travel, which was particularly experienced in the recent pandemic. Risks are so high that currency in travel medicine must include regular participation in briefings and administrative tasks. Numerous venues exist for flight surgeons to mitigate health risks. This program offers international aerospace medicine specialists an opportunity to incorporate some of the latest medical guidelines along with tips and techniques.

Learning Objectives

1. Study updates regarding deployed flight medicine tasks and medications for travel.
2. Discuss good practices for patient care and travel medicine in a deployed environment.
3. Renew USAF requirements for the flight surgeon Comprehensive Medical Readiness Program (MCRP).

[275] FORTIFYING MASS CASUALTY RESPONSE

Mitchell Radigan, Jason Burchett, Douglas Files

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: Enterprising aerospace medicine professionals provide mishap response capability including for aircraft crashes and potential mass casualty scenarios. This presentation encourages professionals to maintain currency by participating in a response exercise. **OVERVIEW:** Aerospace medicine professionals are first-in and may be last-out during disaster relief operations. They analyze the medical aspects of toxic and hazardous materials used on an airfield and they consult on hazardous spills. They may respond to aircraft mishaps, caring for the initial responders as well as those directly injured. This vibrant program will update aeromedical professionals on response issues by providing an opportunity for individuals to participate in a mishap exercise involving a crash or other disaster scenario. **DISCUSSION:** Remaining current in disaster response requires recurring training. Aerospace medicine professionals will improve their understanding of the subtleties of dealing with other airfield organizations (i.e. - fire dept, civil engineering, etc), with federal authorities, and with local facilities that interact with the airfield during disaster responses. Participants will study and discuss the latest disaster response information.

Learning Objectives

1. Discuss the features of investigating a mass casualty or other disaster situation.
2. Interface with military and civilian authorities during a disaster scenario.
3. Renew Comprehensive Medical Readiness program requirements for the flight surgeon career field.

[276] FORTIFYING IN-FLIGHT PHYSIOLOGIC EMERGENCY RESPONSE

Charles Shurlow, Jason Burchett, Douglas Files

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: One common duty of aerospace medicine practitioners is to treat aircrew who suffer physiologic problems in flight. This presentation will use simulated patient cases to train flight surgeons and allied professionals in physiologic emergency response. **OVERVIEW:** Aerospace medicine personnel specialize in the effects of normal physiology in abnormal environments. This program will reinforce in aeromedical professionals' minds how to respond to a physiologic incident. **DISCUSSION:** U.S. military services may require annual updates regarding physiologic incident response. Flight medicine personnel from other nations and from civilian organizations will also benefit. Flight surgeon instructors will demonstrate how to discuss aircrew issues and potential physiologic causes, and also how to treat a patient. This physiologic response discussion will offer flight surgeons an opportunity to learn about responses, incorporating the latest physiologic response information.

Learning Objectives

1. Consider the features of military physiologic incidents, especially in a deployed setting.
2. Interact with other organizations to treat injured aircrew and investigate what occurred during an aviation physiologic incident.
3. Renew Comprehensive Medical Readiness program requirements for the flight surgeon career field.

[277] FORTIFYING AEROMEDICAL EVACUATION

Jason Burchett, Douglas Files

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: Practitioners of aerospace medicine commonly oversee the safety of patients in flight. They may also medically clear patients being transported in an aeromedical evacuation system. The current presentation will encourage professionals to maintain currency by performing medical clearances for simulated aeromedical evacuation patients.

OVERVIEW: Professionals in aerospace medicine specialize in the physiologic effects of flight at altitude. At times, patients with compromised physiology may also be flown. This program will help flight surgeons protect patients being transported in aeromedical evacuation systems. One example might be a patient with pain issues being transported. **DISCUSSION:** Some U.S. military services require recurring training for flight surgeons. Yet some flight surgeons have never participated in aeromedical evacuation cases. This program will give aerospace medicine professionals an opportunity to participate in the medical clearance of simulated aeromedical evacuation patients. It will cover the latest trends and techniques and will be beneficial to all attendees participating in the session.

Learning Objectives

1. Discuss specific features of military aeromedical evacuation out of a deployed setting, transporting patients back to a higher level of care.
2. Interface with other organizations to prepare injured persons for air transport in an aeromedical evacuation situation.
3. Renew Comprehensive Medical Readiness program requirements for the flight surgeon career field.

Wednesday, 05/24/2023**10:30 AM****Grand Chenier****[S-53]: PANEL: IANC AEROSPACE NEUROLOGY PANEL****Chair: Joseph Connolly**

PANEL OVERVIEW: Major goals of Aerospace Neurology, as in all of Aerospace Medicine, include flight safety, mission accomplishment and well-being of aviators and passengers. In this panel we will explore in-flight incapacitation from Transport Canada with the view of using Artificial Intelligence to predict and prevent in-flight incapacitation. This will be followed by a presentation on in-flight incapacitation from the FAA perspective, covering difficulties in medical certification and Special Issuance. Benign Paroxysmal Positional Vertigo (BPPV) can be a cause of sudden incapacitation, disorientation or distraction in flight. We will review the USAF aeromedical waiver program for BPPV through the lens of the published rates of BPPV recurrence and the USAFSAM Aeromedical Consult Service Medical Assessment and Airworthiness Matrix (AMRAAM) versus the actual recurrence rate of BPPV in USAF aviators with waivers compared with the AMRAAM. Cervical disc arthroplasty is a commonly-used procedure, but as these implanted devices have not been adequately proven in the high-G environment and pose a risk for sudden incapacitation, their use is not approved by most militaries for high performance jet pilots. We will review the USAF experience with this setting. Certification challenges from neurologic injuries such as traumatic brain injury (TBI) and cerebral vascular accidents (CVA) focus on subsequent seizure risk (incapacitation) from TBI and CVA recurrence and post CVA seizure risk. We will explore why published seizure rates after TBI by severity and post CVA as well as CVA recurrence may over-estimate the risk for the military aviator population.

[278] A REVIEW OF CRITICAL INCIDENTS CAUSING SUDDEN NEUROLOGICAL INCAPACITATION OF AIRCREW IN FLIGHT. CAN AI SYSTEMS MITIGATE THE RISK OF FATAL OUTCOMES?Christopher Skinner

University of Ottawa, Ottawa, ON, Canada

(Education - Tutorial/Review)

The objective of this presentation is to explore the different types of sudden neurological incapacitation of pilots in flight. These events are

rare but the process of evaluating the effects of these critical events on cockpit operations is lacking. Feedback from agencies investigating accidents due to possible neurological causes should be an essential part of developing evidence based regulatory processes. The presentation will illustrate several different scenarios of neurological incapacitation including the analysis of a case of probable sudden incapacitation of unknown cause. Several other conditions such as seizures, migraine and stroke in the cockpit will be also discussed. The development of AI systems to warn or intervene in such situations using non-invasive sensing systems might assist in mitigating the risk of fatal outcomes and assist aviation safety regulators in development of advanced risk assessment methodologies.

Learning Objectives

1. Discuss different types of sudden neurological incapacitation of pilots in flight
2. Discuss the shortcomings of the current review process of accidents ascribed to sudden incapacitation of unknown cause
3. Discuss several different scenarios of incapacitation including seizures, migraine

[279] INFLIGHT INCAPACITATION CASE STUDIES

Richard Ronan Murphy¹, Farhad Sahiar¹, Roger Hesselbrock²
¹FAA, Oklahoma City, OK, United States; ²FAA, Dayton, OH, United States

(Education - Case Study)

INTRODUCTION: We are presenting illustrative cases highlighting the neurology and aerospace physician's approach to in-flight incapacitation and medical certification. **BACKGROUND:** In-flight events of sudden incapacitation may occur with or without a mishap or accident, but nonetheless pose a serious risk for aviation safety. Numerous medical and physiological reasons exist for sudden incapacitation, all the more so in the aerospace environment. Identification of neurologic or other conditions against this backdrop is challenging. Neurologists are often tasked to help determine the root cause, the risk for recurrence and potential risk mitigation. **CASE PRESENTATION:** Case studies of in-flight incapacitation, evaluated for aeromedical certification, are presented that highlight: 1) Information sources that may be used, and how such information may be obtained, 2) Critical history elements and confounds, 3) Use of ancillary testing. **DISCUSSION:** Determination of aeromedical risk is often challenging in such cases due to incomplete, inaccurate or contradictory information provided post-event. Methodological approaches to improve diagnostic efficiency and accuracy emphasize obtaining first hand, objective and timely historical reports, and consider "drift" in history when information is obtained more temporally remotely from the event. We will also discuss the approach to dealing with persisting uncertainty after events of incapacitation from the aeromedical certification perspective, to include mitigation of risk over time, as well as the timing and usefulness of clinical evaluations and testing.

Learning Objectives

1. The audience will learn about Information sources that may be used in the evaluation of aeromedical risk in cases of in-flight incapacitation, and how such information may be obtained.
2. The audience will learn about critical history elements and confounds in the evaluation of aeromedical risk in cases of in-flight incapacitation.
3. The audience will learn about use of ancillary testing in the evaluation of aeromedical risk in cases of in-flight incapacitation.

[280] AEROMEDICAL CONSULTATION SERVICE MEDICAL RISK ASSESSMENT & AIRWORTHINESS MATRIX AND USAF BENIGN PAROXYSMAL POSITIONAL VERTIGO WAIVER PROCESS REVIEW

John DiModica¹, Roger Hesselbrock², Aven Ford², Michael Lang³, Glenn Nagasawa², Jared Haynes², Joseph Connolly²

¹Wright State University Boonshoft School of Medicine, Centerville, OH, United States; ²Aeromedical Consultation Service, Dayton, OH, United States; ³Epidemiology Consult Service, Dayton, OH, United States

(Original Research)

BACKGROUND: The U.S. Air Force School of Aerospace Medicine (USAFSAM) developed a conceptual framework for a risk matrix approach to evaluating and communicating aeromedical risk; this resulted in the Aeromedical Consult Service (ACS) Medical Risk Assessment and Airworthiness Matrix (AMRAAM). Prior to implementation, the ACS conducted a study to evaluate results using the AMRAAM to results using the legacy ACS risk assessment process; this study included a re-analysis of multiple cases from each specialty represented within the ACS using the AMRAAM. Using available BPPV recurrence data, rates of 15-18% at 1-year and up to 50% in 5-years from the general population, pilots with BPPV did not meet Airworthiness criteria. Applying the AMRAAM to BPPV the likelihood of recurrence is considered Occasional and severity level is considered Catastrophic, resulting in an aeromedical risk score of 4 representing High risk which does not support waiver. This prompted a review of the BPPV waivers issued and outcomes. **DESCRIPTION:** A review of waivers for BPPV from the Aeromedical Information Management Waiver Tracking System (AIMWTS) powered a study to determine the true rate of recurrence for Benign Paroxysmal Positional Vertigo (BPPV) among the US Air Force aviator population. 60 aviators (284 person-years) were included in the final data analysis. Mean age at initial waiver was 36.8 (SD=7.3) years and mean follow-up time was 56.8 (SD=50.2) months. The median time of observation from known resolution to the first aeromedical waiver for BPPV was 6 months (n=50). In total, there were 6 (10.0%) recurrences of BPPV. There were no recurrences in one year (N=60) and six recurrences (24%) over 5 years. Our Kaplan-Meier curve calculated BPPV recurrence-free probability at 85% across 20 years, 95% CI [0.69-0.93]. Post review AMRAAM for BPPV changed the occurrence to Remote with a score of 8-10 representing Serious -Medium risk supporting possibility of waiver. **DISCUSSION:** The differences in outcome may be due to social determinants of health, comorbidity, ascertainment criteria and observation period after recovery before waiver. This program review demonstrates the need for military aviator specific outcome data to predict aeromedical risk and airworthiness in the military aviator population.

Learning Objectives

1. The audience will learn how data from aeromedical databases were used to improve aeromedical risk assessment for cases of Benign Paroxysmal Positional Vertigo (BPPV) in an aviator population.
2. The audience will learn to use raw data from aeromedical databases for the Aeromedical Consult Service (ACS) Medical Risk Assessment and Airworthiness Matrix (AMRAAM).
3. The audience will be able to design studies that target data specific to aviator populations for more pertinent aeromedical risk assessment.

[281] SPINAL DISC ARTHROPLASTY OUTCOMES IN U.S. AIR FORCE AVIATORS: A CASE SERIES

Roger Hesselbrock

FAA, Dayton, OH, United States

(Original Research)

INTRODUCTION: Artificial disc replacement is the standard surgical option for younger patients with intervertebral disc disease. Military aviators with spinal disc arthroplasties have routinely been granted aeromedical waivers for non-high-performance or ejection-seat aircraft operations. However, arthroplasty devices have not been sufficiently tested for stress levels encountered in high-performance aircraft operations or aircraft ejection, which has limited their utility for these aircrews. The U.S. Air Force recently implemented an evaluation process to grant short-term unrestricted waivers to selected aviators with single-level cervical disc arthroplasty. The primary aim of this study was to assess outcomes in military aviators with artificial disc replacement compared to legacy procedures such as spinal fusion. The secondary aim was to specifically review the outcomes of high-performance aircraft crew with single-level cervical disc arthroplasties. **METHODS:** A retrospective record review was performed on 55 military aviators with spinal disc arthroplasty and 73 military aviators who underwent standard surgical procedures, such as spinal

fusion. Flight-hour information was obtained for the arthroplasty subjects. Statistical Analysis was performed using SAS Enterprise Guide® software. Descriptive statistics (Odds Ratio, p-values) were calculated for each variable of interest. **RESULTS:** Average follow up ranged from 1.8 years in high-performance aircrew with single-level cervical disc arthroplasties to 8.1 years for all aviators with legacy procedures. The reoperation rates were comparable between groups. The arthroplasty group had over 6,300 flying hours, including 375 high-performance hours in cervical arthroplasty subjects. Ten single-level cervical disc arthroplasty patients were granted waivers for unrestricted or less restricted flying. No adverse outcomes were noted in this group. **DISCUSSION:** Overall, spinal disc arthroplasty was found to be equivalent to the standard spinal procedures. Single-level cervical disc arthroplasty devices had an uneventful performance in limited follow-up of high-performance aircraft subjects. Correlation with arthroplasty device structural testing is recommended to further validate safety under high-performance aircraft operational stresses.

Learning Objectives

1. The audience will become familiar with aeromedical safety concerns of cervical disc arthroplasty in high performance aircraft operations.
2. The audience will be able to note outcome information in aviators with cervical disc arthroplasty.
3. The audience will become familiar with future studies to assess disc arthroplasty performance under high +Gz stresses.

[282] WHY MILITARY AVIATOR POPULATION NEUROLOGIC OUTCOMES RESEARCH IS ESSENTIAL IN AEROSPACE MEDICINE, SOCIAL DETERMINANTS OF HEALTH ARE A THING!

Joseph Connolly

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

BACKGROUND: Aeromedical concerns after a neurologic event and recovery can be the recurrence of the event such as another stroke or new remote sequelae such as a seizure after traumatic brain injury (TBI) or stroke (CVA). Rates of neurologic event recurrence and sequelae are gleaned from the general population neurologic literature. The recurrence data is then put into a risk acceptance scheme such as the 1% rule or the USAFSAM Aeromedical Consult Service (ACS) Medical Risk Assessment and Airworthiness Matrix (AMRAAM), and an aeromedical recommendation is made. This process ignores the social determinants of health, baseline health and near complete recovery affecting the neurologic event in a military or professional aviator and so likely over-estimates the aeromedical risk. **DESCRIPTION:** Common social determinants of health are socioeconomic status, being subject to racism, gender, housing, neighborhoods, access to healthy food, transportation, education, employment and social support networks. Most military members have favorable social determinants of health, with some stratification by rank, likewise most professional pilots have favorable social determinants of health. We will explore the effect of social determinant of health on traumatic brain injury recovery, stroke rates, stroke outcomes, the incidence of epilepsy and low back pain outcomes. **DISCUSSION:** To estimate the risk of stroke recurrence or seizure in a pilot who has experienced a CVA or TBI requires a study population with specific characteristics that mirror a pilot's social determinants of health and the pilot's recovery from the neurologic event. The ideal study population would have high educational attainment, uniformly excellent health, meeting medical standards, adequate socioeconomic status, decreased discrimination based on race or gender, adequate housing, have good employment and social support networks. Importantly, regardless of the severity of the neurologic injury the subjects in the study population would need to make a near complete recovery and demonstrate the ability to maintain significant employment. Military aviators, or as a surrogate officers, who remain on active duty after a TBI or CVA are the ideal populations to study, to estimate the risk of stroke recurrence or seizure after TBI or CVA in a pilot.

Learning Objectives

1. The audience will learn about the effect social determinants on outcomes from TBI.
2. The audience will learn about the risk of a new diagnosis of epilepsy by occupation in the military.

Wednesday, 05/24/2023
Napoleon Ballroom C1-C2

10:30 AM

[S-54]: PANEL: RESIDENT IN AEROSPACE MEDICINE (RAM) GRAND ROUNDS II

Chair: Serena Aunon

Co-Chairs: Thomas Jarnot, Jonathan Elliot

PANEL OVERVIEW: Resident in Aerospace Medicine (RAM) Grand Rounds consists of 6 clinical case presentations. Each case is presented by current RAMs who will review the clinical case, diagnosis, treatment pathway and current policies from different agencies. The aviator's aeromedical disposition and waiver or special issuance outcome (if applicable) will be discussed. These unique case presentations describe clinical aviation medicine as well as policy updates for common medical and/or mental health conditions encountered in the practice of Aerospace Medicine.

[283] WHAT FACTORS SHOULD FLIGHT SURGEONS CONSIDER FOR PREGNANT PASSENGERS FLYING ON MILITARY AIRCRAFT?

Jesse Schonau¹, Jeffrey Brown²

¹U.S. Navy, Pensacola, FL, United States; ²U.S. Army, Fort Rucker, AL, United States

(Education - Case Study)

Flight surgeons need to consider all the pertinent factors when making recommendations for pregnant women flying on military aircraft as pilots, crew, and passengers. This presentation will use a patient case to review the literature and discuss the military service specific guidelines as well as other civilian guidelines flight surgeons can reference to provide medical recommendations to enhance crew and passengers safety and protect mission integrity when pregnant passengers fly on military aircraft. It will also emphasize the need for the United States Department of Defense to establish a standard to guide military flight surgeons in the decision making process.

Learning Objectives

1. Understand there is no comprehensive guideline covering all the military services that discusses when pregnant patients should be allowed to fly on military aircraft as pilots, crew, or passengers.
2. Understand that military flight surgeons will need to use multiple resources including service specific guidelines and civilian guidelines to make recommendations about when pregnant patients should be allowed to fly on military aircraft.

[284] A CASE OF ALTERNOBARIC-STABLE DECOMPRESSION SICKNESS FROM NASA'S EXPLORATION ATMOSPHERES STUDY

Kristi Ray¹, Isaiah Reeves¹, Robert Sanders², Leisa Deutsch¹

¹UTMB, Galveston, TX, United States; ²NASA JSC, Houston, TX, United States

(Education - Case Study)

INTRODUCTION: This case report describes a research test subject who presented with pressure-resistant Decompression sickness (DCS) symptoms during NASA's Exploration Atmosphere Study. **BACKGROUND:** Exploration Atmosphere is NASA's study to validate prebreathing protocols for planetary EVA's. Subjects lived at a pressure of 8.2 psi and had excursions to 4.3psi for simulated EVAs during a 3 and 11-day study. DCS is a risk due to pressurization changes. Type 1 DCS

most commonly presents as joint pain, and type 2 DCS commonly includes more complicated and severe neurological and cardio-pulmonary manifestations. The accepted DCS risk based on computer calculations is <15% risk of type 1 DCS with no cases of type 2 DCS. Case: A 34 y/o male presented with the development of multiple joint pain >24 hrs after return to sea level. The subject participated in the 11-day study and completed 5 excursions to 4.3psi with no issue. The joint pain started in the bilateral elbows, gradually progressing to include bilateral knees. The pain was described as a deep ache, and did not get better with OTC medications. The subject was evaluated by the on-call physician and was diagnosed with Type 1 DCS. Due to the delayed declaration of DCS, this patient was treated with a USN TT5 at an outside facility. All pain resolved with treatment. **DISCUSSION:** This case represents an aviation/ hypobaric DCS with an interesting presentation that differs from commonly taught pathogenesis (changes in severity correlate with changes in ambient pressure) and stabilization when placed under hyperbaric conditions. The effect of habitation pressure on the natural history of DCS symptoms may be greater than originally thought. If this is the case then a change in nominal and contingency operations may need to occur as NASA prepares for the ARTEMIS missions back to the Lunar surface.

Learning Objectives

1. The audience will learn about NASA's exploration atmospheres and DCS risk.
2. The audience will learn about DCS presentation in hypobaric environments.

[285] DOC, WHY IS MY WRIST NOT GETTING ANY BETTER?

Ryan Thompson

Naval Aerospace Medical Institute, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: A 23-year old U.S. Student Naval aviator presented to the Aviation Medicine department with right wrist pain following golfing injury. This case study report reviews the work up and eventual diagnosis, as well as duty disposition decisions. **BACKGROUND:** Musculoskeletal complaints are incredibly common in the flight clinic and special care is needed examine joint involved, underlying cause, strength, mobility, and duty impact. All aircrew require strength and joint mobility to maintain aircraft stability and safety flight, especially in aircrew who experience +Gz forces or dynamic flight. **CASE PRESENTATION:** A previously healthy flight student presented to flight medicine for right wrist pain, swelling, and decreased range of motion after golfing 3 weeks prior and was sent to physical therapy for treatment. Conservative management for suspected TFC sprain showed no improvement, and subsequent MRI confirmed TFC tear, but also large joint effusions with significant synovitis/debris, multiple bony erosions, and marrow edema suggestive of inflammatory arthropathy. He showed minimal response to initial CSI and NSAID use and extensive rheumatology workup was performed to determine underlying diagnosis. He showed seronegative arthropathy (other than elevated ANA), and additional causes ruled out by laboratory testing. Synovial biopsies showed thickening/significant inflammation, but no evidence of infection or other process. New bilateral rash on extensor elbow surfaces showed psoriasis on biopsy. Therefore, he was diagnosed with psoriatic arthritis by CASPAR criteria and started on disease-modifying antirheumatic drugs for treatment. Given progressive nature of condition and location (stick hand) and side effects of treatment, the student was found not qualified for flight training and continued military service. **DISCUSSION:** This case highlights how the condition and treatment of psoriatic arthritis has significant implications on the deployability and continued flight status of aviators, especially when involving joints integral to flight control. While psoriatic arthritis may affect up to 30% of psoriasis patients, peak diagnosis is not until third to fourth decade of life. As it and other inflammatory arthropathies are progressive, irreversible conditions, recognizing and providing early treatment are essential to maintain quality of life and reduce disability. This is especially true in younger patients.

Learning Objectives

1. Participants will understand the basic workup and causes of undifferentiated early inflammatory arthritis in adults.
2. Learners will review aeromedical duty status eligibility in relationship to psoriatic arthritis.
3. Learners will consider additional occupational concerns in patients taking immunosuppressive therapies.

[286] NEED A HAND? HAND AMPUTATION WITH REPLANTATION IN A PILOT: A CASE STUDY

Dane Newell, Alexander Haley

U.S. Air Force, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case describes an aviator who sustained a traumatic hand amputation. Prompt medical and surgical intervention with extensive rehabilitation led to a positive outcome. **BACKGROUND:** Prior to William Balfour's successful digital replantation in 1814, traumatic amputation of digits or upper extremities was an irreversible injury with potentially catastrophic impact. Over the next 150 yr, surgical techniques and medical technology improved significantly, allowing for the first successful clinical replantations of upper extremities. Developing microsurgical techniques continued to improve outcomes, with successful replantation rates now exceeding 80-90% in some studies.

CASE PRESENTATION: A 26-yr-old female pilot sustained a complete amputation of her left, non-dominant hand across the base of metacarpals after it was pulled through the blade of a table saw. Her spouse was home and placed a tourniquet over the wrist and put the amputated hand on ice. She was transported to the hospital and transferred to a hand replantation specialist for surgery. Successful replantation of the severed hand was performed within 5.5 hours after injury. The aviator underwent extensive rehabilitation with follow-up surgery to release palmar scar tissue. She remained at work performing administrative duties including participating in simulator duties during the recovery and non-flying period. A limited waiver was approved 11 mo post-injury, and she flew a 7-h B-52 sortie without issues. A 2-yr restricted Flying Class II waiver was approved and recently renewed as an unrestricted Flying Class II waiver. She is currently serving as a Reserve B-52 evaluator pilot and flying commercial cargo aircraft with no limitations from the injury.

DISCUSSION: This case highlights how a catastrophic and seemingly career-ending loss of an upper extremity can be successfully treated. Effective pre-hospital interventions with rapid transfer to definitive care allowing for timely replantation, followed by intensive rehabilitation, optimized the patient's outcome, allowing her to regain function and continue a military aviation career. This case emphasizes the importance of both aviators and flight surgeons understanding what pre-hospital interventions should be taken, as well as the importance of rapid transfer to definitive care to allow for the best chance of successful replantation of an amputated upper extremity.

Learning Objectives

1. Describe proper techniques in preserving amputated limbs prior to replantation as well as timelines regarding ischemia of amputated limbs prior to replantation surgery.
2. Describe the Federal Aviation Administration processes for special issuance and Statement of Demonstrated Ability (SODA) in the civilian aviator.

[287] BUSTING THE MYTHS: A CASE STUDY ASSESSING THE RISK OF ASTHMA IN A FIGHTER PILOT

Shana Hirschert, Monica Pierce-Wyong

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case study describes a pilot with undetected asthma leading to an in-flight emergency. **BACKGROUND:** Asthma is a chronic inflammatory lung disease with common symptoms of dyspnea,

shortness of breath, and cough, but it is often asymptomatic in athletic patients. An aviator with underlying asthma is at high risk of an exacerbation, particularly in high-performance aircraft. **CASE PRESENTATION:** A 31-yr-old male F-16 pilot presented to clinic after three physiologic in-flight emergencies. After the third incident involving shortness of breath at altitude as well as dizziness, pulmonary function tests were obtained that showed a moderate obstructive pattern. The aviator denied any symptoms of dyspnea or exercise intolerance. Lung function normalized with tobacco cessation and treatment with Fluticasone/Salmeterol. Based on his aeromedical risk, he was given a 1-yr Flying Class IIC waiver with limitations of no routine use of aviator mask, no high-performance aircraft, and flying only with another qualified pilot. His waiver requires pulmonary function tests every 6 mo and annual follow-up with Pulmonology. **DISCUSSION:** There is a high prevalence of asthma in elite athletes. Fighter pilots often have similar exercise routines that may predispose them to asthma in a similar fashion. These groups may experience dyspnea less frequently than other populations. Environmental exposures common in flight can trigger a life-threatening bronchospasm. The United States is the only North Atlantic Treaty Organization country that is not screening for lung disease in pilot candidates. Screening could be used to vector candidates to airframes with less triggers, limiting exacerbations and risk of worsening. Guidelines that encourage pulmonary function tests after physiologic events may identify at-risk individuals, allowing early treatment and possibly delaying or slowing of worsening lung function in this highly trained and specialized population. Fully trained pilots have been granted waivers for well-controlled disease, and there has been a significant recent increase in flight-approved medications, which widens the aperture for waivers. Flight surgeons should educate the flying community of the risks as well as ease their fear of being removed from flying duties.

Learning Objectives

1. Describe how to evaluate patients with suspected asthma and educate them on common misconceptions.
2. List the safety concerns with lung disease and high-performance, single-piloted aircraft.
3. Describe the use of risk assessment to educate both the aviator and leadership.

[288] MEDICAL EVALUATION AND CLEARANCE OF NASA ASTRONAUTS WITH ATRIAL FIBRILLATION

Michael LaBarbera, Brian Hanshaw

UTMB, Galveston, TX, United States

(Education - Case Study)

INTRODUCTION: This case series describes the medical clearance of NASA astronauts after diagnosis of atrial fibrillation seeking to fly to the International Space Station (ISS). **BACKGROUND:** Atrial fibrillation is the most common sustained arrhythmia with increasing incidence with age and is associated with increased lifetime risk of stroke. Treatment may consist of pharmacologic rate control and anticoagulation. Although it is not yet known how spaceflight modifies risk of cardioembolic event or adverse treatment effects, these can have significant impact on mission and crew health for spaceflight and granting a medical waiver for flight is a complex, case-by-case consideration. **CASE PRESENTATION:** We reviewed all records of waivers granted by NASA for atrial fibrillation and flutter, and identified 6 cases (4 short-duration [<18 days] and 2 long-duration missions [>60 days]) where waiver was granted with subsequent spaceflight. **DISCUSSION:** NASA has approved astronauts with a history of atrial fibrillation or flutter for flight following an appropriate medical evaluation. With the high prevalence of atrial fibrillation in the general population, we anticipate that consideration of medical waiver will become increasingly common as commercial spaceflight grows. These cases provide a potential framework for risk assessment and management of this population, to balance potential risk modification inherent in the microgravity environment against implications to crew performance, mission success, and personal health of spaceflight participants.

Learning Objectives

1. The audience will gain an appreciation for the potential crew health and mission considerations for considering medical waiver in cases of atrial fibrillation.
2. The audience will gain an appreciation for the impact of spaceflight, crew performance, and health risks in treatment of atrial fibrillation.

Wednesday, 05/24/2023
Napoleon Ballroom D1-D2

10:30 AM

[S-55]: PANEL: CLINICAL PRACTICE GUIDELINES- AEROMEDICAL RISK ANALYSIS

Chair: Daniel Van Syoc

PANEL OVERVIEW: Annual review of timely medical conditions of importance to both the military and civilian aviation communities. Presenters will share topics, treatments, and any recent research, and emphasize standard development or modifications. Will address standards from the US military services and civilian policy from FAA perspective.

[289] ADJUSTMENT DISORDERS, PART 1

Terry Correll

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: The U.S. Air Force School of Aerospace Medicine Aeromedical Consultation Service's Neuropsychiatry Branch regularly reviews and evaluates aviators with a diagnosis of adjustment disorder, which is our most prevalent diagnosis. Such a diagnosis is disqualifying, typically impairs the ability of the aviator to fly, and can damage mission effectiveness. **TOPIC:** Extended "down" times for the aviator are common in aviators with adjustment disorders. It is very common for aviators with adjustment disorders to be prescribed a long-term antidepressant, receive no psychotherapy, and even not to be evaluated and treated by mental health. This presentation discusses the treatments for adjustment disorder along with the potential waiverability following treatment and stabilization of the aviator. When managed well, many adjustment disorders never require "down" periods, and even when they do, their length can be minimized. **APPLICATION:** Excellent evaluation and management (including potentially healthy lifestyle interventions, psychotherapy, and medication) can not only minimize and even avoid "down" periods, but can enhance resilience to avoid recurrence of similar future episodes. A discussion of problems noted with aeromedical summaries and waiver packages will be addressed. Although specific for US Air Force pilots and aircrew evaluated at the Aeromedical Consultation Service, the underlying issues are common to aviators and waiver processes in all the military services and civilian organizations. **RESOURCES:** 1. Wood J, Heaton J, and Van Syoc D. Post-Traumatic Stress Disorder (PTSD) (June 2017). In: Air Force waiver guide. Wright-Patterson AFB (OH): U.S. Air Force School of Aerospace Medicine; 2019. 2. American Psychiatric Association (Ed.). (2022). *Diagnostic and statistical manual of mental disorders: DSM-5-TR* (Fifth edition, text revision). American Psychiatric Association Publishing.

Learning Objectives

1. To understand the impact that adjustment disorders have in the aviation community.
2. To discuss risk assessment, management, and mitigation for US Air Force aviators and aircrew with adjustment disorders.

[290] ADJUSTMENT DISORDERS, PART 2

Ryan Peirson

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Conceptualized as a trauma- and stressor-related disorder, Adjustment Disorder is a common and often minimized

disorder. In fact, it is the most common diagnosis (26% reviewed for waiver at the U.S. Air Force (USAF) Aeromedical Consultation Service (ACS) (26%). Disqualifying for all classes of flying in the USAF. Depending on the severity and duration of the presentations, adjustment disorder may or may not require a waiver. **TOPIC:** Part 2 of this presentation will focus on the not-anticipated occurrence of Adjustment Disorder as the most commonly referred diagnosis to the ACS Neuropsychiatry branch and potential factors that contribute to this phenomenon. Additionally, the experience of using medication treatment, which is not a scientifically validated or generally accepted approach, and potential reasons of this will also be discussed. Due in part to its status as representing a cluster of symptoms often less intense or numerous than other disorders (for example, Major Depression or Generalized Anxiety), and the influence of third-party payers in limiting available treatments or levels of care, it can be misconceived as a low-level syndrome. Risk for suicide, risk for future or comorbid disorders, treatment, and aeromedical risk mitigation will be discussed in this teaching session. **APPLICATION:** Adjustment Disorder is a prevalent condition among military members and is potentially waiver-eligible in USAF aircrew. Excellent evaluation and management (including potentially healthy lifestyle interventions, psychotherapy, and medication) can minimize DNIF periods, and can enhance resilience to avoid recurrence. This presentation will highlight these concepts and is primarily relevant to USAF flight surgeons, but it also has utility for other military services and civilian flight medicine. **RESOURCES:** 1. Dickey M, Heacock K, Van Syoc D, Speakman R, Adjustment Disorder (Aug 2020). In: Air Force waiver guide. Wright-Patterson AFB (OH): U.S. Air Force School of Aerospace Medicine; 2022. 2. American Psychiatric Association (Ed.). (2022). *Diagnostic and statistical manual of mental disorders: DSM-5-TR* (Fifth edition, text revision). American Psychiatric Association Publishing.

Learning Objectives

1. The audience will understand the status of formal medication approval for Adjustment Disorder.
2. The audience will understand the great variability in Adjustment Disorder presentations.

[291] SAURON: SOPHISTICATED ARTIFICIAL INTELLIGENCE USE REGARDING OPHTHALMOLOGIC NEEDS. A PRIMER

Jonathan Ellis

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

TOPIC: The ACS Ophthalmology Branch has used published data regarding certain eye conditions as well as findings within the management groups to craft recommendations for changes/advances in vision standards for the USAF. The use of Artificial Intelligence (AI) has expanded rapidly as a method of pattern recognition to identify associations among data sets that may not be readily apparent to the human observer. The ACS Ophthalmology Branch has begun a multi-year study to use AI to review data sets within select management groups. This presentation will discuss what SAURON is, the progress of the initial study that is currently underway and the planned future studies that will be completed using SAURON, as well as the strengths and limitations of AI used for deep learning in Ophthalmology and Aerospace Medicine. **APPLICATION:** Discuss AI use in deep learning for Ophthalmology and Aerospace Medicine to advance vision standards. **RESOURCES:** Ting DSW, et al. Artificial Intelligence and Deep Learning in Ophthalmology. *Br J Ophthalmol*. 2019 Feb;103(2):167-175. Balyen L, Peto T. Promising Artificial Intelligence-Machine Learning-Deep Learning Algorithms in Ophthalmology. *Asia Pac J Ophthalmol (Phila)*. 2019 May-Jun;8(3):264-272. Ferro DL, et al. The Upcoming Role of Artificial Intelligence (AI) for Retinal and Glaucomatous Diseases. *J Optom*. 2022 Oct 7;S1888-4296(22)00054-1. Online ahead of print.

Learning Objectives

1. The audience will learn the conditions the ACS Ophthalmology plans to investigate using SAURON.

2. The participant will learn how AI has been used in ophthalmology in other investigations and how that can be applied to vision standards.
3. The listener will learn what SAURON stands for.

[292] ASAMS AEROMEDICAL RISK ANALYSIS: CHRONIC OBSTRUCTIVE PULMONARY DISEASE

Charles Mathers

FAA, Washington, DC, United States

(Education - Program/Process Review)

BACKGROUND: Chronic obstructive pulmonary disease (COPD) is a major cause of morbidity and mortality worldwide. COPD has significant aeromedical implications, from symptoms including exertional dyspnea and fatigue, hypoxia at typical cabin altitudes in commercial aircraft, and the potential for pulmonary barotrauma. While there is much scientific literature dedicated to the assessment of COPD patients traveling as passengers in aircraft and to high-altitude terrestrial destinations, very little research has focused specifically on evaluating pilots with COPD.

OVERVIEW: This talk will provide an overview of recent efforts to update Federal Aviation Administration (FAA) policy regarding pilots with COPD, including implementation of a new condition an AME can issue (CACI) and AME-assisted special issuance process (AASI). **DISCUSSION:** The presentation will cover evidence-based clinical decision-making tools to evaluate pilots with COPD such as the GOLD multi-dimensional assessment, the utility and significance of the 6-minute walk test and its correlation to high altitude simulation testing, and review ICAO and military service specific policies for evaluating pilots with COPD. It will conclude with a brief overview of research efforts at the Civil Aerospace Medical Institute evaluating pulmonary physiologic criteria associated with safe operation of an aircraft.

Learning Objectives

1. Understand the aerospace medical implications of Chronic Obstructive Pulmonary Disease.
2. Understand the FAA's updated process for evaluating pilots with COPD.

[293] TRAPS, ARTEFACTS, LIMITATIONS AND OPPORTUNITIES OF MENTAL HELATH SCREENING INSTRUMENTS

Marion Venus^{1,2}

¹Venus-Aviation Research, Training & Pilot Support, Universität Bern; ²Institut für Psychologie, Zurich, Switzerland

(Education - Program/Process Review)

BACKGROUND: EASA made the mental health assessment of pilots mandatory after the Germanwings crash. In this context, ASMA and other organizations have recommended the use of established screening tools for the mental health assessment of pilots, in context with their first and recurring medical class 1 certification. **DESCRIPTION:** Even though this recommendation sounds reasonable, there are limitations regarding screening instruments. Positive screening results are not diagnoses. Screening instruments cast a finer net and discover more suspected cases than can be confirmed diagnostically, regarding depression, anxiety, and common mental disorders. Individuals with positive screening results should be examined psychologically and diagnostically for possible existing depressive or anxiety disorders. Artifacts must be avoided, e.g., what looks like a positive depression screening (PHQ8/9 \geq 10) might be an exhausted, severely fatigued pilot, whose mood is impaired due to exhaustion and roster-related sleep deprivation. What may look like a positive anxiety screening result (GAD \geq 10) or generalized anxiety disorder, maybe a pilot, who fears losing his medical class 1 certification due to excessive fatigue, exhaustion, and progressing health problems. The worried pilot with positive anxiety screening may also fear a crash or accident due to microsleep events at the controls. Item scores of depression and anxiety screenings are compared

with item scores of fatigue item ratings (Fatigue Severity Scale), sleep problems and mental health. **DISCUSSION:** Recent research results do not imply a 'sudden outbreak' of depressive or anxiety disorders among pilots. High rates of positive depression and/or anxiety screenings indicate that many pilots are exhausted and – associated with high levels of fatigue, sleep problems and sleep restrictions – suffer from impaired mood, irritability, and worries. Knowing about safety risks associated with fatigue in the cockpit, many pilots are worried about flight safety, their jobs, and their livelihood. Along with aeromedical examiners, clinical and aviation psychologists should cooperate regarding qualified evidence-based decisions in case of mental health issues, fitness to fly, and the medical recertification of pilots.

Learning Objectives

1. The audience will learn about the weaknesses of screening instruments for the mental health assessment
2. The audience will learn about the most common artifacts and traps, when mental health screening instruments are used for the mental health assessment of pilots.

[294] A COMPARATIVE STUDY BETWEEN AN INDIGENOUS PSYCHOMETRIC TEST BATTERY 'PSUMEDHA' AND 'COGSCREEN-AE'

Anitha T, Vipin Sharma, Sowgandhi Ch N, Punyashlok Biswal
Institute of Aerospace Medicine, Bengaluru, India

(Original Research)

INTRODUCTION: In today's combat environment, a pilot's duty necessitates a higher level of precision, agility, speed, attention, memory, situational awareness, risk assessment, and planning. The critical aspect of the psychometric testing is to assess these distinctive abilities of the pilot. 'pSuMEDhA' an indigenous test battery robustly evaluates the impact of aviation stressors on the cognitive abilities of the pilot. Furthermore Cogscreen-AE is a cognitive screening instrument which assesses deficits or changes in the cognitive abilities and extensively used in pilot testing. The present study aimed to compare the performance measures of these psychometric test batteries. **METHODS:** Randomly selected healthy adults (N=50, M=32, F=18) who met the inclusion criteria were administered both the psychometric test batteries with an interval of 24 hours. The comparable variables identified are speed measures, accuracy measures and process measures of the psychometric tests that taps the vigilance, reaction time, dual tasking, working memory, attention, visuo-spatial orientation and executive function of the participant. The comparable variables pertaining to speed, accuracy and process measures were analyzed using Bland Altman analysis and Pearson's product moment correlation coefficient. **RESULTS:** The mean age of the sample was 31.78 \pm 0.74 yr. The speed and accuracy measures of tests tapping working memory were found to be congruent as the plots were within the upper and lower limits of agreement (mean diff- 0.25 sec, p value= $<$ 0.0001) and **r value of 0.6** implying pSuMEDhA would assess the corresponding cognitive domain optimally. Other comparable variables showed insignificant correlation. **CONCLUSION:** Few tests of pSuMEDhA and CogScreen AE assess the same cognitive ability with distinct administration methods. However, each cognitive test battery measures the individual differences with respect to cognitive abilities effectively. pSuMEDhA, designed for military aviators, has a test that assesses the risk index of the individual. Whereas, CogScreen AE is designed for screening of neurocognitive dysfunction and Taylor's aviation factor score in an aviator. Further, the exclusive variables demonstrated uniqueness in the design of the tests fulfilling the purpose for which they were developed.

Learning Objectives

1. Understand about the psychometric test batteries which assess cognitive functions of a pilot and deficits if any.
2. Acquire knowledge or widen the horizon on two unique psychometric test batteries by their comparable outcome variables that taps same cognitive abilities of the individual.

Wednesday, 05/24/2023
Napoleon C3

10:30 AM

[S-56]: PANEL: MAXIMIZING VALUE OF IN-FLIGHT ENVIRONMENTAL & PHYSIOLOGICAL DATA FROM A JOINT PERSPECTIVE.

Chair: Stephanie Warner
Co-Chair: Christopher Dooley

PANEL OVERVIEW: Globally, many efforts exist to develop and integrate devices to monitor physiologic status and environmental conditions experienced by tactical aviators. However, non-standard approaches to validation, airworthiness, data merging, and integration can result in challenging decisions regarding technology transition and acquisition, ultimately increasing the timeline for delivery to the fleet. This panel will review a method used to maximize the value of in-flight physiologic data from a joint Department of Defense (DoD) perspective. Researchers from the Naval Medical Research Unit-Dayton (NAMRU-D), the 711th Human Performance Wing (HPW), the Naval Air Warfare Center Aircraft Division (NAWCAD) Human Systems Engineering Department, and the Naval Air Systems Command (NAVAIR) will describe the step by step process using information from existing studies. **PANEL STRUCTURE:** The first presentation describes NAMRU-D's process for hierarchical validation and evaluation of environmental and physiological monitoring systems prior to transition for flight testing. The second presentation describes the requirements necessary to achieve airworthiness via a specific effort by NAVAIR and NAWCAD to flight test an environmental and physiological sensing system developed by Dräger. The third presentation describes an approach for merging multiple streams of data via an effort by the 711th HPW to develop a wired, integrated cockpit sensing system. The fourth presentation describes a wire-free method by NAVAIR/NAWCAD, and Athena GTX to integrate various sensing systems into a single low power blue tooth enabled hub to stream data from multiple sensors in order to assess pilot state. The final presentation will address the strategic view of how the current pool of data will be used in a pilot warning system, as well as the pitfalls and successes regarding how to best leverage the existing data and ensure that appropriate and correct information is shared across services.

[295] HIERARCHICAL VALIDATION & EVALUATION OF ENVIRONMENTAL & PHYSIOLOGICAL MONITORS FOR MILITARY AVIATION

Stephanie Warner¹, Dain Horning¹, Samantha Keller², Jesse Leiffer², Joseph Williamitis³, Margaret Gallagher²

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

(Education - Program/Process Review)

BACKGROUND: There is high awareness across the aeromedical research and military health system communities regarding the efforts to develop devices to monitor the physiologic status and environmental conditions experienced during military aviation. Successful development efforts should result in validated, reliable, and accepted devices prepared for in-flight use. However, the process to evaluate and validate the performance of each device and prepare it for fleet use has been less socialized. Utilizing VigilOX as an example, this presentation will inform the relevant communities of the initial and necessary phases of a hierarchical approach to validate and evaluate environmental and physiological monitors under simulated aviation conditions. **OVERVIEW:** NAMRU-D, in collaboration with the 711th HPW, NAVAIR, and NAWCAD, developed and implemented a multiphase verification and validation (V&V) protocol to evaluate environmental and physiological monitoring systems. The approach involved unmanned benchtop, environmental, and hypobaric chamber testing, manned normobaric testing, and manned simulated flight testing

(e.g., altitude chamber and centrifuge). To ensure consistency across the device evaluation, predefined accuracy requirements were identified as qualifications to move to the next phase of testing. As most of the devices were developmental, these procedures were iterative and incremental, allowing device improvements to be made throughout the process. This initial qualification approach ensures suitability, accuracy, and reliability of each device to measure its specified variables. Consistent application of a pre-defined V&V protocol minimizes risk associated with cost, schedule delays, and poor device performance in the tactical aviation environment. **DISCUSSION:** To support the safety of military aviators, much time and resources have been dedicated to developing environmental and physiological monitors. To maximize the value of the data, equivalent care should be given to the evaluation of these devices' performance in an operationally relevant environment. Thus, given the differences in variety and sensing mechanisms in environmental and physiological monitors, having a standardized, repeatable, and applicable performance evaluation approach is crucial. Utilizing this cross-service, iterative, hierarchical approach will indicate preparedness for transition to airworthiness and flight testing, moving each device one step closer to fielding.

Learning Objectives

1. The audience will learn about the standardized approach used by United States Navy and Air Force researchers to transition environmental and physiological monitoring systems from unmanned benchtop to manned simulated flight testing.
2. The audience will learn about the qualifications required to transition environmental and physiological monitoring systems from verification and validation testing to flight testing.

[296] ACHIEVING AIRWORTHINESS APPROVAL FOR AN ENVIRONMENTAL AND PHYSIOLOGICAL SENSOR

Rachael Ryan

Department of the Navy, Patuxent River, MD, United States

(Education - Program/Process Review)

This presentation describes the requirements necessary to achieve airworthiness for a specific system to measure the gas and pressure within the oxygen masks, as part of the effort to understand a sub-set of physiological conditions of Naval Aviators in flight. A Cooperative Research And Development Agreement (CRADA) was established to collaborate with industry partners, in this case Draeger, to have a single piece of hardware (AviAir) containing an oxygen sensor, a carbon dioxide sensor, and a pressure sensor in fluid connection with the Navy's existing MBU-23 oxygen mask assembly, with the requirements of deploying the system for collection of data during all phases in flight in T-45 training aircraft. This presentation details how requirements documented in a Requirements Verification Trace Matrix (RVTM) specified which stage of testing performance would be verified as well as what would be needed to achieve approval of an Interim Flight Clearance (IFC) for flight testing, what tests were required for Fleet Data Collection, and what further level of qualification was needed to be considered fully Fleet fieldable. Verification methodologies along with documentation requirements from SMEs in the IFC approval chain were documented in an Engineering Data Requirements Agreement Plan (EDRAP) that was shared across the AviAir team to ensure all testing was being conducted and reported out in a manner that would result in approval for the IFCs. The following tests verified functionality of the AviAir system with the MBU-23/P and were necessary as part of the Airworthiness process:

1. Laboratory Testing: Altitude Chamber (unmanned at NAVAIR), ROBD, Gear Fit, Windblast, EMI, and Environmental.
2. Laboratory Testing (Brooks City Base and NAMRU-D): Altitude and Centrifuge chamber (manned).
3. Ground Testing: Fit check and flight control snag hazards test to be conducted on test articles to ensure the AviAir does not degrade the performance or usability of aircraft flight controls.
4. Flight Testing: Conducted in order to gather actual data during the flight of T-45 aircraft. This includes the use of an actual pilot

connected to the AviAir system. The system must be able to collect and measure O₂, CO₂, and mask pressure continuously during flight.

5. Fleet Data Collection: Manufacture a limited set of sensor units and conduct on-site data collection with T-45 Instructor Pilots at Kingsville and Meridian Naval Air Stations (NAS).

Learning Objectives

1. The audience will learn about Engineering Data Requirements Agreement Plan Process.
2. The participant will learn about the Airworthiness Process for NAVAIR/NAWCAD.

[297] INTEGRATED COCKPIT SENSING (ICS): CHALLENGES IN REAL-TIME DATA FUSION AND CONTEXTUAL INTERPRETATION

Chris Dooley

711th Human Performance Wing, Wright Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: Unexplained physiologic events (UPEs) in the high performance aircraft (HPA) environment stem from complex, multifactorial insults. The National Commission for Military Aviation Safety, in their report published in Dec 2020, identified the need for persistent physiologic and environmental monitoring of the HPA pilot. Multiple efforts across the US Department of Defense (DoD) and industry have taken on the challenge of addressing this need. **OVERVIEW:** The Integrated Cockpit Sensing (ICS) program is an ongoing effort led by the 711th HPW, in coordination with Ball Aerospace. The program aims to develop a modular capability, separate of the aircraft systems and power, which enables for real-time aggregation and analysis data pertaining to LSS performance, cockpit environmental conditions, and airmen physiology in high performance aircraft. The foreseen benefit of the system is two-fold. Firstly, providing actionable in-flight alerting for pilots, reducing physiological risk and ultimately preventing adverse physiologic events. Secondly, the system will be integral in creating a database of holistic aircraft-airmen performance in-flight data that will allow for mission performance improvement as well as detailed forensic analysis of future UPEs. The ICS system integrates high-TRL miniaturized and wearable sensors, integrated via the GOTS COG Pack open architecture, and applies data fusion and machine learning to generate accurate, actionable alerts to pilots. With the constant improvement of physiologic systems, the ICS system is modular and able to incorporate new/improved GOTS/COTS sensors as they become available due to its open architecture design and algorithms agnostic of specific sensing technologies. **DISCUSSION:** Ever more insightful work is ongoing in DoD and civilian labs for understanding the human-machine interactions that occur in the HPA cockpit environment. Transitioning, and expanding upon, that knowledge requires data collected in the cockpit environment, from multiple sensing elements, to be appropriately fused to ensure accurate context is conveyed. Successfully overcoming these challenges opens the aperture for what is possible in the HPA cockpit for improving human-machine interactions in the realms of both safety and performance.

Learning Objectives

1. Understand the value add of multiple data streams in the context of the high performance aircraft environment.
2. Learn about techniques for time synchronization of disparate sensing systems.

[298] PHYSIOLOGICAL MONITORING: WIRE-FREE INTEGRATION TO STREAM SENSOR DATA AND ASSESS PILOT STATE

Raisa Marshall¹, Bridget Rinkel³, Maura Kilgore⁴, Amanda Muller², Erin Benson², Sean Mahoney², Casey Boutwell³, Nichola Lubold⁴, Dan Ratcliff⁵, Christine Wood¹

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²Athena GTX, Johnston, IA, United States; ³NIRSense, Richmond, VA, United States;

⁴Honeywell Aerospace, Phoenix, AZ, United States; ⁵Naval Air Systems Command, Patuxent River, MD, United States

(Education - Program/Process Review)

BACKGROUND: Physiological monitors measure human responses to detect and warn of degraded cognitive or physical performance. Numerous challenges are associated with adapting clinical monitoring concepts and integrating devices for use in a tactical air environment. The devices need to be evaluated against environmental extremes encountered in high-performance flight and identify changes in human physiology. The US Navy has mounted a considerable effort to evaluate physiologic and environmental sensors to develop an aircrew monitoring and warning system (AMWS). This involves a collaborative effort with the US Air Force that is partially funded through the Defense Innovation Unit. The physiological monitoring capability must track environmental and physiological systems to autonomously interpret aircrew status. Several prototype devices designed to operate independently were tested and evaluated, none of which were a complete AMWS. A proof of concept effort to create this unified wire-free system that provides aircrew state in real-time began in June 2021. **OVERVIEW:** The goal of the AMWS is to track oxygenation (cerebral tissue and blood), heart rate and variability, breathing rate and patterns, aviator mask gas and pressure, acceleration, and ambient pressure and temperature. The system uses these data to estimate aircrew physiologic state, workload, fatigue, and cognitive status. Wire-free Bluetooth Low Energy (BLE) protocol links the sensors. The challenge is to connect and time sync signals from different BLE transmitters, determine signal quality, derive measurements on a small processing unit, input them into status algorithms, determine aircrew status and alert aircrew. **DISCUSSION:** The system's core is the HsHub, derived from Athena GTX's Holistic Modular Aircrew Physiologic Status (HMAPS) monitoring system that has been successfully tested in-flight. It serves as the communications nexus and status arbiter. Athena GTX is demonstrating the prototype HsHub with its HMAPS peripheral devices (environmental sensor and ECG patch), Honeywell Biosensing Apparel (compression t-shirt or sports bra), and NIRSense cerebral tissue oximeter. Apps were developed and bench tested to display real-time data on smartwatch platforms with an alert function. HsHub function and life support equipment compatibility will be dynamically tested in the altitude chamber, centrifuge, and in-flight with the assistance of the Patuxent River Flight Test Squadron.

Learning Objectives

1. The audience will learn about the next step in the evolution of developing and validating an aircrew physiologic monitoring and warning system.
2. The audience will learn about the types of sensors considered core to an aircrew physiologic monitoring system.
3. The audience will learn about obstacles to overcome when integrating systems together into a wire-free platform.

[299] CONTINUED FAA MEDICAL CERTIFICATION OF FIRST AND SECOND CLASS PILOTS WITH INSULIN TREATED DIABETES USING CONTINUOUS GLUCOSE MONITORING TECHNOLOGY

James DeVoll¹, Lynn Stanwyck², Joyce Pastore¹, Richard Murphy¹, Bernice Batres³, Petrolina Chilaka⁴, Zykevis Gamble⁵

¹FAA, Washington, DC, United States; ²Virginia Tech Carilion School of Medicine, Roanoke, VA, United States; ³University of California Jonathan and Karin Fielding School of Public Health, Los Angeles, CA, United States; ⁴University of Texas Health Science Center at Houston, Houston, TX, United States; ⁵Howard University, Washington, DC, United States

(Original Research)

INTRODUCTION: In November 2019, the FAA announced a new protocol to evaluate pilots with insulin treated diabetes mellitus (ITDM) for special issuance (SI) medical certification for first/second class pilots. This program leveraged the emergence of continuous glucose monitoring (CGM) technology in the treatment and of monitoring pilots with ITDM. A previous study examining two years of data showed pilots certified under this protocol meet or exceeded clinical standards for diabetes. The purpose of this study was to further evaluate the characteristics of pilots

with ITDM who were initially certificated, recertificated or denied medical certification. **METHODS:** Data was collected retrospectively from the FAA Document Imaging Workflow System (DIWS) for pilots considered for a first/second class SI under the ITDM program between November 2019 and September 2022. Inclusion criteria required a certification decision (SI vs. denial) under the ITDM program. We extracted de-identified data on demographics and CGM parameters including average glucose, coefficient of variance (CoV), time > 250mg/dl (%), and time less than 70-80 mg/dl (%). We compared these parameters between pilots issued a SI vs. denial with Mann-Whitney U-tests and Fisher exact tests using R. We also compared the pilots certified between October 2021 and September 2022 with those previously certified. **RESULTS:** 68 received SIs and 28 were denied. Of these, 13 of the pilots were granted SI after October 2021 and 9 were denied. 60 pilots renewed their SIs. Pilots granted an SI were older (45.5 versus 25.5 years old, $p = <0.001$), had a lower hemoglobin A1c (6.4% versus 7.1%, $p < 0.001$), lower average glucose (140 mg/dl versus 156 mg/dl, $p < 0.001$), and lower CoV (26.8 versus 35.5, $p < 0.001$), and spent less time with low (1% versus 3%, $p < 0.001$) glucose levels. There were no statistically significant differences between pilots certified before versus after October 2021. **DISCUSSION:** This program has shown enduring and robust consistency in effectively differentiating between pilots for whom ITDM is safely mitigated for both initial and recurrent certification. This program will continue to evolve with the clinical and technological advances in the field of ITDM, and we expect many more pilots with the condition will be able to achieve safe certification.

Learning Objectives

1. The audience will learn about the continuation of the FAA's ITDM protocol for first/second class pilots.
2. The participant will be able to describe clinical characteristics of a successful applicant for a first or second class medical certificate under the ITDM protocol.

Wednesday, 05/24/2023
Napoleon Ballroom A1-B3

10:30 AM

[S-57]: PANEL: IMPROVING THE FUTURE TODAY: AEROMEDICAL RESEARCH AND PILOT-PHYSICIANS

Sponsored by the International Association of Military Flight Surgeon Pilots

Chair: Thomas Powell
Co-Chair: Chris Bates

PANEL OVERVIEW: *The audience will learn about emerging technology currently being implemented in United States Air Force aviator training and future potential avenues for development. Through a series of presentations, the learners will become more educated on the roles Pilot-Physicians occupy to further the general Aerospace Enterprise by acting as clinicians, educators, and researchers to continue to expand the knowledge of Aerospace Medicine and their contributions to educating the next era of Aviators. Topics to be discussed will include aircrew screening, training, procurement of new equipment, safety, and human factors. This panel of Pilot-Physicians and their team members will discuss new developments, training insights, and point to the direction of their future endeavors. As new technologies continue to be incorporated within aviator training pipelines, this panel will explore the benefits and potential pitfalls of these technologies. With a foot in both the operations and medical world, these insights will be invaluable to guiding the path of inspiring the next generation of aviators and ensuring their safety and effectiveness for the years to come.*

[300] THE FUTURE OF U.S. AIR FORCE PILOT TRAINING AND IMPLICATIONS FOR FLIGHT SURGEONS

Andrew Pellegrin

U.S. Air Force, Joint Base San Antonio-Randolph, TX, United States

(Education - Program/Process Review)

BACKGROUND: Undergraduate pilot training (UPT) in the United States Air Force is undergoing a major shift as it transitions away from the legacy system of producing pilots, which has been largely unchanged for the past 50 years. This new system of producing pilots, termed "UPT 2.5" includes incorporation of virtual reality simulation as a new training modality, increased flexibility in the training syllabus to tailor training to the individual student, and incorporation of human performance training with athletic trainers, dieticians, and cognitive performance specialists embedded within flying training squadrons. Future changes include a phasing out of the T-1 Jayhawk aircraft that is currently used to train mobility pilots and incorporation of additional paths to pilot qualification that do not include the current primary pilot training platform, the T-6 Texan II. These additional paths include a helicopter only track and a civilian path to wings whereby civilian pilots who meet specific training and experience requirements may bypass primary pilot training in the T-6 and enter training at a later point in the training pipeline bound for mobility, special operations, or surveillance aircraft. **OVERVIEW:** This presentation will provide current data regarding UPT 2.5 graduates' performance as compared to graduates of legacy pilot training. The presenter will also discuss ongoing questions and opportunities for future research. Such opportunities include determining whether the data gathered in the human performance evaluations now included in the UPT 2.5 syllabus predict flying performance in the program and determining appropriate medical standards for pilots entering the civilian path to wings who will not fly high performance aircraft at any time during their career as Air Force pilots. **DISCUSSION:** These current and future changes provide both challenges and opportunities for Air Force flight surgeons who care for student pilots as well as flight surgeons who care for operational pilots whose training and experience as they arrive to their first operational flying units may be significantly different than in the past. Lessons learned from this ongoing process will be broadly applicable to other military services and to all those who provide medical care to aviators.

Learning Objectives

1. Participants will learn about ongoing changes in U.S. Air Force undergraduate pilot training (UPT 2.5) and how these changes may impact the medical needs of pilots during training and after arrival to their first operational flying units.
2. Participants will learn about human performance optimization programs that are incorporated into UPT 2.5 and the impact these programs have had on student pilot performance.

[301] SPATIAL DISORIENTATION TRAINING: MULTI-DISCIPLINARY DEVELOPMENT FOR THE ROTARY-WING SIMULATOR

Steven Gaydos¹, Alaistair Bushby², Ian Curry³

¹HQ Army Air Corps, Army Aviation Centre, United Kingdom; ²RAF Centre of Aviation Medicine, RAF Henlow, United Kingdom; ³U.S. Army Aeromedical Research Lab, Fort Rucker, AL, United States

(Education - Program/Process Review)

BACKGROUND: Spatial Disorientation (SD) results from improper sense of aircraft position, motion, or attitude with respect to the fixed coordinate system of the earth's surface and the gravitational vertical. SD remains a significant cause of aviation mishaps including the military rotary-wing (RW) operational environment. Within the British RW community, SD remains a causal or contributory factor in about one-third of serious accidents and carries a disproportional penalty with respect to accident severity and fatalities. **OVERVIEW:** With the operational requirement to fly increasingly complex platforms within challenging environments, the threat of RW SD remains significant, particularly at times of high workload and deceptive visual cues. The British tri-Service Consultant Advisors in Aviation Medicine endorsed a multi-modal, layered approach for SD mitigation that now includes interactive synthetic training systems. For the AW159 Wildcat helicopter, training scenarios were jointly developed from a team including aerospace medicine physicians, qualified helicopter instructors, and simulation technicians. **DISCUSSION:** It was

recognized that multi-disciplinary input was highly advantageous with each specialty bringing differing experiences and diverse perspectives. This “whole-of-team” approach also served to encourage and empower non-medical stakeholders within the aviation community to take larger ownership of SD mitigation ensuring that the operator threats, safety issues, and mitigation measures are not viewed solely through the lens of a medical discipline.

Learning Objectives

1. Participants will broadly recognize inherent advantages of multi-disciplinary developmental approach to SD mitigation including involvement of a pilot-physicians.
2. Participants will appreciate a multi-modal approach to spatial disorientation training including the use of high-fidelity simulation and synthetic trainers.

[302] NORMOBARIC HYPOXIA EMERGENCY IN TACTICAL F/A-18 HORNET SIMULATOR AS TOOL IN CRM TRAINING FOR FIGHTER 4-SHIP AND GCI

Tuomo Leino¹, Heikki Paavilainen², Nikke Varis³

¹National Defence University Finland, Kuusa, Finland; ²Finnish Defence Forces, Tampere, Finland; ³University of Tampere, Tampere, Finland

(Original Research)

INTRODUCTION: Physiological episodes are an issue in military aviation including 5th generation fighters. Already 2008 normobaric hypoxia training in F/A-18 Hornet simulator (WTSAT) was developed in Finland to allow pilots to recognize individual symptoms of hypoxia and to execute hypoxia emergency procedures (EPs) in 100% identical cockpit environment. Pilot-physicians have been instructors in this training and nowadays hypoxia training can be done with 4 simulators and fighter controller (GCI) in same network. This makes crew resource management (CRM) training also possible using hypoxia emergency in one pilot as tool for team training. **METHODS:** The simulator flight was DCA sortie as 4-ship formation lead with SKATE tactics in BVR air combat against hostile fighter formation. Seven pilots participated the study. 8% of oxygen in nitrogen was used to provide normobaric hypoxia for 4-ship lead pilot. AMRAAM missile shooting distance and brake distance were analyzed from WTSAT data and shown as percentage from optimal. Bold face hypoxia EPs included: 1) green ring pull (100% emergency oxygen) 2) OXY flow knob off 3) emergency decent with 20 degrees nose-down attitude to MSA. **RESULTS:** With 8 % oxygen lead aircraft shooting distance was 30% too close and brake distance 31% too close. During brake, 6 pilots out of 7 ordered lead role change to 2-ship lead pilot. Rest of fighter formation had to cover lead aircraft out from enemy missile envelope.

DISCUSSION: Team CRM included CGI help during emergency decent to safe sector and loose control information about threat. After 3 minutes empty emergency oxygen bottle was simulated by closing breathing valve. RTB was done at low altitude in radar trail formation and post-hypoxic pilot as number one in radar trail. Annual hypoxia training can also be used for CRM training in simulator network. Line Orientated Flight Training (LOFT) approach offers valuable and safe experience for pilots and GCIs about the effects of hypoxia in fighter environment. Wingman and another 2-ship have their roles in emergency situation and this method helps to achieve also their training goals.

Learning Objectives

1. Hypoxia, although treated with 100 % oxygen, have an effect on 4-ship air combat due to hypoxia hangover i.e. long lasting cognitive impairment.
2. Normobaric hypoxia in simulator network offers a CRM training tool for fighter pilots and fighter controller (GCI).

[303] THE GUINEA PIG EXPERIENCE- LESSONS LEARNED AS A HUMAN TEST SUBJECT

Thomas Powell

377 Operational Medical and Readiness Squadron, Albuquerque, NM, United States

(Education - Program/Process Review)

BACKGROUND: Spatial Disorientation remains a killer of aircrews and their passengers. Despite decades of knowledge on the subject and great automation to prevent its development, it remains a dangerous pathology for humans operating in the aerospace environment. Even still, there are questions that have yet to be answered about its development and prevention. Training programs must teach new aviators about its insidious dangers and how to recognize and prevent symptoms. With more sophisticated centrifuges and simulators, we are learning more about these unanswered questions and developing better ways to recognize it, but these endeavors require human volunteers to test these hypotheses.

OVERVIEW: These new, more sophisticated simulators and centrifuges require both novice and experienced aviators to fully determine the differences in spatial disorientation development across a variety of factors such as workload and hypoxia. This presentation will describe my experiences as one of these human test subjects. **DISCUSSION:** By utilizing a centrifuge combined with a flight simulator, an experience very close to actual flight can be simulated to produce a high-quality, reproducible scenario which may induce spatial disorientation. Variables such as workload, body positioning, and breathing-gas mixture can be manipulated and their results measured. To adequately explore these variables, motivated test subjects are required to fully explore these new effects. Subjects with little to no aviation experience function as surrogates for untrained aviators, whereas experienced aviators can be placed as controls. The results of these experiments can then be applied to the training realm to allow planners to develop more effective training and equipment that reduces spatial disorientation as well as allowing novice aviators to recognize it more quickly with the effect being an overall safer aviation environment. It is the presenter's hope that by having others hear about these experiences as a human test subject, more individuals will volunteer for these cutting-edge studies to expand the envelope of knowledge and make for a safer aerospace environment for all.

Learning Objectives

1. Learn about recent research in spatial disorientation and its frontiers.
2. Learn about how spatial disorientation research improves our understanding of this dangerous phenomenon and can help training programs save lives.
3. How important it is to have motivated and eager human test subjects for these studies.

[304] USAF PILOT PHYSICIAN PROGRAM 2023, WHERE ARE WE NOW?

Christopher Backus

55th Medical Group, Bellevue, NE, United States

(Education - Program/Process Review)

BACKGROUND: Pilot physicians meld two disciplines central to aerospace medicine and thus have been central to the Association. As we discuss the next generation of aerospace, it is easy to focus on scientific and technical education at earlier levels, but it is also important to see how established programs change to meet the demands of this next generation. **OVERVIEW:** The United States Air Force pilot physician program allows operators with expertise in aerospace medicine to use both areas to further research in human performance, human factors, and human system integration. Gaining credibility in operations and medicine is time intensive and requires rare candidates. In the current climate of decreased resources to support advanced technology, the program has changed to most efficiently bring these operational medical experts to bear on the highest priority operational problems. This discussion focuses less on aeromedical research and more on the program that develops and enables one advanced type of researcher. **DISCUSSION:** In the third decade of the 21st Century, unique challenges present to the aeromedical researcher. While fourth generation fighters typically had two seat variants, fifth generation fighters do not, meaning the only chance for a physician to fly in the F-22 or F-35 is in the case of the pilot physician. Other examples include the KC-46, an innovative new approach to air refueling that

required design changes after fielding to reach full capability and pilot physicians were essential to that effort. Increased striving for diversity in aircrew mean that crewmembers that were previously excluded from the aerospace environment are seeking full inclusion, bringing attention to risks that are not fully characterized. Pilot physicians who have been in that environment stand ready to better describe those risks. A strained pilot training pipeline could not afford delays just when a new oxygen system threatened to induce delay. Hard to describe subjective physiological symptoms that are difficult to objectively measure in the cockpit environment benefit from experts who can ethically expose themselves to the environment, informing their approach to resolving the root causes. These lessons apply across services and among international partners.

Learning Objectives

1. The audience will learn about the current United States Air Force pilot physician program.
2. The participant will understand some differences between the current USAF pilot physician program and the program 10 years ago.
3. Attendees will understand some of the drivers that led program change and how those changes serve to make an effective program in the current environment.

[305] OPERATIONAL IMPACT OF NECK AND BACK PAIN FOLLOWING IMPLEMENTATION OF A HUMAN PERFORMANCE PROGRAM FOR FIGHTER AIRCREW

Joe Zhang

U.S. Air Force, Langley AFB, VA, United States

(Education - Program/Process Review)

INTRODUCTION: Neck and back pains are common complaints in the fighter community. Historically, this population experiences higher rates of injury than the general population. The USAF conducted a survey modeled after the NATO HFM RTG 252 recommendations in 2020 for all fighter aircrew and established an embedded human performance program for the career field. A follow up survey was conducted in 2022 to gauge the effects of the program. This is the first time that the NATO style survey has been repeated for a population. **METHODS:** All USAF fighter aircrew received an on-line anonymous survey that utilized the core questions from the NATO Aircrew Neck Pain Prevention and Management Human Factors and medicine research task group 252 report. All aircrew with a designation of 11F (Fighter Pilot) or 12F (Fighter Weapons officer) positions were allowed to participate including instructors, students, active, reserve, and non-current flying personnel. **RESULTS:** 2029 responses were received from 6500 anonymous surveys sent electronically making it the largest of its type ever performed. This is an increase from the prior survey which had 1962 responses. Significant findings include 98.3% and 92.3% of aircrew reported flying related neck pain and back pain respectively. 74.8% report current pain. 70% reported difficulty moving their head while pulling G's. 96.0% reported that these pains affect their quality of life in off duty settings. 82.6% and 82.4% claim to have never reported their neck and back pains respectively to a medical authority. This is up significantly from the prior survey which reported 40% failure to report rate. 50.3% have also taken themselves off the flying schedule at least once due to pain. **DISCUSSION:** These results reaffirm musculoskeletal pain to be a significant issue affecting fighter aircrew. More interestingly however, is that there appears to be a significant difference in responses when there is a well-functioning human performance program in operation. Even after just a single year, the more fully established human performance bases showed a 2.1-6.7% improvement in various cockpit functional movements when compared to bases without a working program. This type of information will help to refine existing human performance programs and provide interim benchmarks for future endeavors.

Learning Objectives

1. Gain an understanding of prevalence of neck and back pain in USAF fighter aircrew.
2. Gain an understanding of the operational impact of chronic pains on USAF fighter aircrew.
3. Gain an understanding of impact of human performance programs.

Wednesday, 05/24/2023

Nottoway & Oak Alley

10:30 AM

[S-58]: POSTERS: SPACE MEDICINE POSTERS 1

[306] A NOVEL MODEL PREDICTING THE RISK OF UROLITHIASIS DURING LONG-DURATION SPACEFLIGHTS

Ganeev Singh¹, Robert O'Connell², Lisa McNamee³, Philip Brady⁴, Derek Hennessey⁵

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²University College Dublin School of Medicine, Dublin, Ireland;

³Space Medicine Ireland, Dublin, Ireland; ⁴Trinity College Dublin School of Medicine, Dublin, Ireland; ⁵Mercy University Hospital, Cork, Ireland

(Original Research)

INTRODUCTION: Urolithiasis is the development of urinary calculi and is a potential complication of prolonged exposure to microgravity. Ureteric stones have many negative complications, which include incapacitating pain, sepsis, renal failure, and death. The aim of this study is to determine the theoretical risk of urolithiasis during long-duration space missions using a model derived from spinal cord injury (SCI) patients who are known to be physiologically similar to astronauts. **METHODS:** The prevalence of urolithiasis following a SCI and bone mineral density (BMD) loss at the great trochanter was determined in SCI patients through literature review. This was compared to BMD loss in astronauts to develop a linear model of the theoretical risk of urolithiasis in microgravity equivalent to $H(x) = (-16.39)x$, where $H(x)$ is the hazard risk of nephrolithiasis per 1,000 person years, -16.39 is the leading coefficient, and x is the rate of change of the percentage of BMD loss. **RESULTS:** At the greater trochanter, BMD loss following SCI is -7.7% at three months, -11.7% at six months, and -14.9% at a year. Correspondingly, the prevalence of urolithiasis after SCI is approximately 43 cases per 1,000 person-years at three months, 43 cases per 1,000 person-years at six months, and 15 cases per 1,000 person-years at one year. In microgravity, the BMD loss is also rapid at $-1.4 \pm 0.8\%$ /month, equating to -4.65% at three months and -9.3% at six months. Using an SCI model of BMD loss and urolithiasis prevalence, we project that the instant prevalence of urolithiasis in microgravity is 26.08 cases per 1,000 person-years per month with an R-squared (R^2) value of 0.6327. **DISCUSSION:** This is the first study that aims to determine the risk of urolithiasis during long-duration spaceflights. The projected rate of the prevalence of urolithiasis in microgravity is likely multiple times higher than in Earth's gravity, which is approximately 0.02 – 0.14 cases per 1,000 person-years. Until more non-theoretical data is available to better calculate the risk of urolithiasis, we recommend that space agencies use counter-measures during future missions to reduce this risk and have contingencies in place should astronauts develop renal colic.

Learning Objectives

1. Learn about the differing risk factors for urolithiasis between microgravity environments and Earth's environment.
2. Understand the theoretical risk of urolithiasis during long-duration spaceflight based on spinal cord injury patients and known bone mineral density loss.
3. The need to recommend space agencies to develop risk mitigation strategies based on the projected urolithiasis risk model.

[307] DELIVERING REMOTE CARE: USING THE MICROSOFT HOLOLENS 2 TO FACILITATE VIRTUAL MUSCULOSKELETAL EXAMS

Adam Levschuk, Jocelyn Whittal, Ana Luisa Trejos, Adam Sirek
Western University, London, ON, Canada

(Original Research)

INTRODUCTION: Musculoskeletal (MSK) injuries are among the most common injuries reported in space. Physical assessment of an injury is essential for diagnosis and treatment. Unfortunately, when MSK injuries

occur in space the flight surgeon is limited to 2D video conferencing and potentially, observations from the crew medical officer. We investigated the feasibility of using the Microsoft HoloLens 2 mixed reality headset to facilitate 3D physical MSK shoulder exams. **METHODS:** To evaluate the feasibility of using HoloConnect for physical MSK exams we conducted a simulated international holoportation event between Western University in London, Ontario, and Huntsville, Alabama. The exam was performed by a medical student, and a healthy adult male was used as a simulated patient. The physical exam of the shoulder was based upon the shoulder exam as described in Bates Guide to the Physical Examination and included inspection, palpation, and strength and range of motion (ROM) testing. **RESULTS:** Inspection of the shoulder was completed by having the simulated patient slowly turn so all parts of the joint could be visualized. Self-palpation of all bony architecture was completed with guidance. ROM testing was completed in three degrees of freedom. Strength testing that required the resistance of gravity was completed, while strength and ROM testing requiring resistance or joint manipulation supplied by the examining physician could not be performed. **DISCUSSION:** During inspection, the anatomically correct size of the hologram made examination of the joint realistic. However, improving graphics quality towards 1080p and above would make subtle changes in the joint, skin, and bones more recognizable. Self-palpation of the shoulder joint worked better on the anterior aspect of the joint. The posterior components of the joint, such as the scapula, were more difficult to self-palpate, and in a person with less flexibility, could be completely inaccessible. The weightless environment of space would require another person, or a machine, to be used when evaluating the strength of the joint. Finally, compared to 2D video conferencing, holoportation felt more 'human', and organic, and could help maintain the value of physician-patient relationship while administering care remotely. As durations of space flights become longer, more work needs to go into developing methods to provide high quality physical exams to astronauts.

Learning Objectives

1. Learners will learn that administering a MSK physical exam is feasible with holoportation and confers subtle advantages compared to traditional 2D video conferencing.
2. The weightless environment of space and physical separation of physician and patient limits some aspects of the physical exam. Moreover, new methods for examining the strength of a joint in space need to be developed.

[308] HEIGHT OF FALL NEEDED TO SUSTAIN TRAUMATIC INJURIES IN LUNAR AND MARTIAN ENVIRONMENTS

Kimberly Burke¹, Margaret Siu¹, Craig Nowadly², Tovy Kamine¹

¹University of Massachusetts Chan Medical School-Baystate, Springfield, MA, United States; ²Brooke Army Medical Center, San Antonio, TX, United States

(Original Research)

INTRODUCTION: Treatment of traumatic injuries sustained during space travel entails limitations not experienced on Earth. Conservative management is preferable, but prevention of injuries is key. To better understand space travel traumatic injuries and prevent possible injuries, we calculated the approximate height needed from a fall in Lunar and Martian environments to cause various injuries. **METHODS:** Velocity (v) required to cause various injuries was calculated as $v = \sqrt{2\Delta t/m}$. F is an injury specific constant obtained from literature. Impact time (Δt) was estimated using data from velocities and heights of impacts consistent with values determined in gymnastics and motorcycle collisions on Earth. Mass (m) was assumed to be an 80kg astronaut + 48kg primary life support system (PLSS). The height from fall (h) needed to cause trauma was calculated in Lunar and Martian gravity wells. Height was determined using $(v^2)/2g$, where g was individualized gravity. **RESULTS:** F for concussion=3800N, rib fracture=148N, splenic injury= 1120N, and femur fracture=4300N. v for concussion=6.09m/s, rib fracture=6.7m/s, splenic injury= 11.2m/s, and femur fracture=8.7m/s. In a Lunar gravity environment: h for concussion=11.4m, rib fracture=13.9m, splenic

injury= 38.5m, and femur fracture=23.5m. In a Martian gravity environment: h for concussion=5.0m, rib fracture=6.04m, splenic injury=16.8m, and femur fracture=10.3m. LD50 for fall on the moon = 88m and on Mars =38.5m compared to 14.5m on Earth. **DISCUSSION:** Despite the multiple assumptions involved in this study, we found that a significant fall would be required on the moon and Mars to cause any major injury, likely in excess of the height of any currently planned lander or building. Further, the speed of travel of the lunar rover is unlikely to have velocity high enough to cause major injury should an astronaut be thrown from it in a collision. However, given the lack of a compression zone and other safety features of a future lunar rover, speed of travel should be kept to less than 4.5 m/s to minimize risks of major injury.

Learning Objectives

1. The audience will understand the likelihood of major traumatic injury in a Lunar and Martian environment.
2. The audience will understand the falls from differing heights necessary to cause major injuries in a Lunar and Martian environment.

[309] OPPORTUNITIES FOR PRECISION HEALTH UTILIZATION TO SUPPORT ASTRONAUT HEALTH AND PERFORMANCE AT NASA

Lauren Schrader¹, Carol Mullenax², Corey Theriot³

¹Universities Space Research Association, Houston, TX, United States; ²NASA JSC, Houston, TX, USA; ³UTMB, Galveston, TX, United States

(Original Research)

INTRODUCTION: The field of precision health (PH) offers novel approaches to personalized health and medical care, from diagnostics and treatment to tools for the maintenance and support of health. These PH approaches hold great potential to support astronaut health and performance, addressing individual variability in responses to the unique environment of spaceflight. At present, various PH tools and techniques are available terrestrially and many more are in development, stemming from both research and clinical settings. In this new and evolving landscape, opportunities to utilize PH for spaceflight risk mitigation and health support must be actively sought, matching needs with potential solutions. **METHODS:** As a first step in the utilization of PH solutions at NASA, an assessment of PH-relevant opportunities was performed using the Human Systems Risk Board (HSRB) risk categories, each of which represent a health outcome or exposure of concern in the spaceflight environment. Risks were identified with individual variation recognized as a significant contributor in causal mapping. This list was then further narrowed to include risks with existing PH-relevant needs as top risk targets, which were paired with known or future PH solutions. **RESULTS:** Six risks were identified as top risk targets for PH solutions: Immune, Microhost, Pharm, Spaceflight-Associated Neuro-Ocular Syndrome (SANS), Sleep, and Muscle. For each of the top risks, information was catalogued regarding the risk's PH-relevant needs, relevant currently available terrestrial PH solutions as identified from a market search, as well as potential future PH solutions. Other risks of interest identified with potential PH relevance included Food & Nutrition, Cardiovascular, Radiation Carcinogenesis, Behavioral Med., Sensorimotor, and Medical. **DISCUSSION:** The identification of human spaceflight risk targets that pair to PH solutions represents a key step in the development of PH-powered mitigation approaches to reduce risk and improve crew health and performance at NASA. Periodic review of the PH landscape will allow for the incorporation of new PH solutions as they become available, providing valuable insights to inform future risk mitigation strategies.

Learning Objectives

1. This poster will summarize efforts in identification of precision health opportunities at NASA and match them to current and future precision health technologies.
2. The audience will learn about areas of individual variability in response to spaceflight conditions, and the relevant precision health solutions that could reduce risk and improve crew health.

[310] PRECISION HEALTH SOLUTIONS TO IMPROVE SLEEP DURING SPACEFLIGHT USING NUTRACEUTICALS

Vasilis Mavratsas¹, Lauren Schrader², Carol Mullenax³, Corey Theriot³

¹UTMB, Galveston, TX, United States; ²Universities Space Research Association, Houston, TX, United States; ³NASA JSC, Houston, TX, United States

(Original Research)

INTRODUCTION: Several differences in astronauts' sleep performance during spaceflight compared to the surface of Earth have been well-documented, including decreased sleep duration, decreased slow-wave sleep and circadian desynchrony. These findings are likely the reason that sleep-promoting and stimulant medications are among the most frequently used by astronauts during spaceflight missions. Current remedies have lacked a precision health approach in their implementation as well as the desired efficacy. Prescribed medications also have the potential for undesirable side effects, dependence, tolerance, and withdrawal. In addition, long-duration exploration class missions will present new challenges that may render current countermeasures more difficult to implement, such as insufficient drug shelf life and restrictions on mass and volume with the inability to replenish supplies. Nutraceuticals provide a possible solution to these problems. **METHODS:** A literature review was conducted on the effects of spaceflight on sleep, the consequences of these effects, and sleep-promoting nutraceuticals. Online database searches included PubMed and Google Scholar. Investigations were selected by targeted searches of primary literature as well as review articles describing the effect of various plant-derived compounds on sleep performance. Available literature was reviewed, and nutraceuticals were assessed for their suitability for use in exploration class spaceflight missions, with an emphasis on a precision health approach. **RESULTS:** Various compounds that have a proven or presumed positive effect on sleep were identified and assessed for efficacy and ease of implementation. Humulone, contained in hops, and L-theanine, contained in the tea plant, were identified as promising nutraceutical solutions that can replace or supplement current pharmaceutical countermeasures. Genetic polymorphisms influencing either circadian rhythm or metabolism of neurotransmitters and their receptors could be a great tool for individualizing sleep solutions in the future. **DISCUSSION:** The alpha acids in hops, particularly humulone, and the amino acid L-theanine in tea are compounds with proven efficacy based on multiple studies that could easily be implemented using a precision health approach in long-duration exploration class missions. Identified polymorphisms provide potential targets for precision health individualization in addition to currently available phenotypic approaches.

Learning Objectives

1. The audience will learn about the effects of spaceflight on sleep.
2. The audience will learn about the biochemical pathways involved in promoting or hindering sleep as well as differences in genotype and phenotype between individuals that can guide a precision health approach to improving sleep.
3. The audience will learn about nutraceuticals that have the potential to provide precision health solutions to improving sleep during spaceflight, the mechanisms by which they exert their effects, and advantages over currently employed strategies.

[311] SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME: A BRIEF FOR ASTRONAUT CANDIDATES

Shilpi Ganguly¹, Catie Cole², Scott Wallace³, Sara Mason⁴, C. Robert Gibson⁵, Mary Van Baalen⁶, William Tarver⁶, Ann Tsung⁷, Tyson Brunstetter⁶

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(Education - Tutorial/Review)

INTRODUCTION: Spaceflight Associated Neuro-ocular Syndrome (SANS) was first described in 2011 as a clinical process involving degradation of visual acuity and structural changes of the eye when exposed to microgravity. This syndrome poses a risk to astronaut vision, safety, and mission performance, especially during extended-duration missions. The modern astronaut cohort is a diverse group of men and women including scientists, engineers, teachers, pilots, business professionals, and artists. Given their diverse backgrounds, it is imperative all crews are educated on SANS risks and potential countermeasures. This education must be comprehensive and easily understood, regardless of academic background or specific expertise. **TOPIC:** A PowerPoint was created to serve as a presentation and stand-alone educational aid for all astronaut candidates (ASCANS). This medium was chosen as it can be updated dynamically as new information emerges. The brief was split into sections to facilitate organized delivery of complex content in easy-to-understand components. Sections included descriptive statistics, signs and symptoms, outcomes, myths and ongoing research, countermeasures, ongoing surveillance, and unknown and future directions. More research is necessary in order to understand this syndrome, and without continued ASCAN participation in research, acquisition of data will not be possible. These efforts will become increasingly critical with deep space and exploration missions. **APPLICATION:** We recommend regular use of this brief for all ASCANS, and potentially veteran crewmembers, given the high risks and potentially poor outcomes associated with SANS. For ASCANS, recommendations include that this brief be provided at the start of their training, with a bi-annual refresher course for all astronauts. This ensures they are current on SANS information, given the dynamic nature of this syndrome. Additionally, this brief will be made available to all as a self-study aid, utilized as a refresher immediately prior to launch. It is anticipated that this brief will promote the health, safety, and wellbeing of professional and private crews alike, during and after long-duration spaceflight.

Learning Objectives

1. The audience will be able to describe current Spaceflight Associated Neuro-ocular Syndrome (SANS) findings, significance, and countermeasures.
2. The audience will understand the importance of astronauts' familiarity with SANS prior to flying and the large risks associated with this syndrome.

[312] USE OF CALCULATED RISKS BASED ON DIRECT ACYCLIC GRAPH PATH ANALYSIS TO REDUCE NASA'S HUMAN SYSTEM RISK BOARD OF RENAL STONE RISK FROM RED TO YELLOW

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(Original Research)

INTRODUCTION: NASA's Human System Risk Board (HSRB) categorizes the Renal Stone Risk (RSR) as Red for a Mars mission, defined by the likelihood and consequence (LxC) score assigned based on the best evidence for a mission. The HSRB uses directed acyclic graphs (DAGs) to visualize the relationships between factors that contribute to each risk. The RSR DAG shows the chain of events that link physiologic changes in spaceflight to nephrolithiasis and delineates the events that must occur to impact mission outcomes that can change the LxC score. Recent updates assigned an LxC score for RSR as 4x4 (Red) for Mars. Medical PRA modeling provides estimates of the probability of occurrence of nephrolithiasis for a given mission duration. However, there is often confusion about whether nephrolithiasis is an outcome or a contributing risk factor. This study evaluates the use of the DAG as a communication tool for aligning subject matter expertise of the definitions and relationships between factors that contribute to risk and

those that are outcomes that inform LxC assignment. **METHODS:** Using data from NASA's Integrated Medical Model risk of nephrolithiasis in a 2-year Mars mission and available evidence from medical literature, we use the Renal Stone DAG to assign probabilities to nodes and identify the relevant probability chains that inform outcomes. 'What if?' scenarios are explored to demonstrate the value of the DAG structure in helping to inform LxC scoring approaches. **RESULTS:** Using the HSRB board configuration managed Renal Stone DAG, a 'What if?' walkthrough using conservative estimates for the probability of occurrence demonstrates the value of this back-of-the-envelope technique for assessing LxC scores. An example scenario is presented that estimates the chance of Loss of Mission Objectives due to renal stone at 0.85% for a 2-year Mars mission. **DISCUSSION:** This study discusses a quick assessment technique for LxC scoring using publicly available DAGs from the HSRB and evidence from the medical literature. This example 'What if?' case uses conservative estimates to inform likelihood and consequence values that can then be assigned a score. While this is not a complete probabilistic model, the rapidity with which this technique can provide a defensible estimate for scoring is valuable for SMEs responsible for working risk assessment, and the association with visualization provides an easily communicated and understood walkthrough for LxC assessments.

Learning Objectives

1. The audience will learn about how DAG's can be used to diagram causal network pathways for human spaceflight risks.
2. The audience will learn a rapid analysis technique using DAGs to assess mission-level outcomes and LxC assignments.
3. The audience will be able to describe the currently understood factors that contribute to the development of symptomatic renal stones in spaceflight and the likelihood that the condition will lead to negative mission-level outcomes.

[313] PRINCIPLES FOR TERMINATION OF MEDICAL CARE IN AUSTERE ANALOG ENVIRONMENTS FOR DEVELOPMENT OF SPACEFLIGHT PROTOCOLS

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¹Eastern Virginia Medical School, Norfolk, VA, United States; ²New York Institute of Technology College of Osteopathic Medicine, New York, NY, United States; ³University of Colorado, Aurora, CO, United States

(Original Research)

INTRODUCTION: When compared to operations in low Earth orbit, exploration class missions will have substantially limited resources and ground medical support while the risk of a significant medical event is projected to be higher. There may be medical conditions which require termination of care (TOC) to minimize the total risk to crew life and to ensure mission success. NASA has identified TOC as a necessary requirement for deep space missions and are currently developing the framework for these protocols. We aim to utilize data from earth-based analogs to identify common principles that can help develop future guidelines to this complex medical and ethical challenge. **METHODS:** A comprehensive literature review was conducted in Medline, nasa.gov, Defense Technical Information Center (DTIC) and google scholar. Key search terms including "withdrawal of care, termination of care, termination of CPR, military medicine, wilderness medicine, futility, potentially inappropriate" and others were used to identify analog studies of relevance. These were qualitatively evaluated for recurring principles or themes that were reviewed and structured. **RESULTS:** Mission planning termination of care principles: definitions of clear medical goals, separate protocols for each relevant condition, protocols developed using best available evidence, crew involvement in development, protocols rehearsal pre-launch, and inclusion of palliative capabilities. In-mission termination of care principles: 1. Crew Medical Officer directed stabilization of the patient 2. Consultation with mission control with standardized information exchange 3. Multidisciplinary medical and ethical conference among the mission directors, flight surgeons and relevant specialist experts.

4. Multidisciplinary risk review examining both medical and mission risks for relevant options 5. Provide a transparent explanation of the process and decision to crew. 6. Allow crew feedback and inquiry to review board 7. Support the crew in the enacted decision. **DISCUSSION:** By utilizing the best available evidence in conjunction with expert opinion we have identified common principles from earth-based analogs that could be used to help design future TOC protocols.

Learning Objectives

1. Common Earth analog termination of care principles and protocols in austere and extreme environments.
2. The utility of termination of care contingency plans prior to flight.
3. A sample protocol emphasizing common principles for flight.

[314] A REVIEW OF VENOUS THROMBOEMBOLISM DURING HUMAN SPACEFLIGHT

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(Original Research)

INTRODUCTION: Recent evidence following the finding of a deep venous thrombosis (DVT) during spaceflight has prompted the need to clarify mechanisms and risk of venous thromboembolism (VTE). In turn, mitigation countermeasures, diagnostic modalities, and treatment options must be explored. The objective of this literature review was to provide a current synopsis of the evidence and knowledge gaps of VTE during human spaceflight. **METHODS:** A literature review was performed from inception to October 2022 pertaining to VTE in the context of spaceflight or ground-based analogues with human participants. PubMed was searched for papers written in English using the terms "spaceflight" or "weightlessness" and "thrombotic" or "embolism" or "thromboembolism" in "venous" or "veins". Papers using cellular or animal models were excluded. **RESULTS:** 60 papers were captured; 8 original scientific, 4 narrative reviews, 2 systematic reviews and 3 commentaries discussed VTE in spaceflight. Reference lists were screened. Important themes included: 1 paper described a VTE occurrence during spaceflight and a partially occlusive thrombus in a second astronaut. 11 studies demonstrated increased venous distension and pressure with decreased flow. 3 studies reported increased fibrinogen levels, 3 studies reported hypoalbuminemia or increased coagulation markers, and 2 papers reported increased pro-inflammatory cytokines or decreased cytotoxic T-lymphocyte function. Additional risk factors may be seen in females in spaceflight, including those ingesting oral contraceptives (OCPs) resulting in increased viscosity. **DISCUSSION:** Venous stasis and decreased shear stress secondary to headward fluid shifts may induce inflammatory changes in the venous system, resulting in endothelial damage and upregulation of the coagulation cascade. Additionally, women in space are subject to physiological factors increasing their VTE risk, such as oral contraceptive use, inducing increased blood viscosity and hypoalbuminemia. Our recommendations include instating thrombophilia screening where appropriate and including oral anticoagulants with reversal agents in the onboard medical kit. Efforts should also be placed in optimizing sensitivity and specificity of imaging markers, payload and training ability, notably the use of vector flow imaging, and improving point-of-testing biomarkers, such as albumin and p-selectin.

Learning Objectives

1. The audience will learn about the effects of spaceflight on Virchow's Triad and the gaps in current literature regarding spaceflight-associated venous thromboembolism.
2. The audience will learn about various screening, diagnostic, and treatment approaches for VTE that should be considered for exploration class missions.

[315] CHANGES IN PERIVASCULAR SPACE FOLLOWING LONG DURATION SPACEFLIGHT: A SYSTEMATIC REVIEW AND FUTURE DIRECTIONS

Maria Bederson¹, Michael Pozin¹, Suguna Pappu², Arian Anderson³

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(Original Research)

INTRODUCTION: Some astronauts returning from long duration spaceflight suffer from symptoms related to alterations in brain structure and intracranial fluid shifts. A possibly related condition is spaceflight-associated neuro-ocular syndrome (SANS). Although initially, increased intracranial pressure (ICP) due to cephalad fluid shift in zero-gravity was hypothesized to be a major factor in the development of SANS, recent findings have brought this theory into question. The glymphatic system, a novel-defined brain-wide pathway of connecting perivascular spaces (PVS) responsible for glial-dependent waste clearance in the CNS, may play a role in the development of SANS and other neurologic conditions associated with prolonged exposure to zero-gravity. The goal of this study is to review emerging literature characterizing changes in PVS following long duration spaceflight. **METHODS:** A systematic review was performed to assess the current understanding of PVS fluid shifts following long duration spaceflight following PRISMA guidelines. PubMed, OVID, and Scopus were searched by independent researchers using the terms: perivascular space, glymphatic system, and spaceflight. Inclusion and exclusion criteria were determined a priori by authors. **RESULTS:** 24 studies were identified in the initial search and 3 were included for review. The included studies utilized T1-weighted MRI for visualization of the PVS of astronauts before and after spaceflight. Barisano et al. found an increase in PVS volumes in all astronauts returning from long but not short duration spaceflight. Hupfeld et al. found an increase in PVS volumes in novice astronauts returning from long duration spaceflight missions on the ISS but not experienced astronauts (>1 previous spaceflight mission). Interestingly, experienced astronauts had larger PVS and lateral ventricular volumes at baseline. Barisano et al. found a correlation between increased pre- and post-flight and PVS volumes and development of SANS, but Hupfeld et al. did not. **DISCUSSION:** The role of the glymphatic system in neuropathology is still emerging. However, the increased PVS volume documented following long duration spaceflight may reflect its function as a major component of fluid homeostasis in the CNS. Further characterization of the PVS changes seen in the zero-gravity setting is necessary to elucidate its relationship with the development of SANS and may contribute to a deeper understanding of the glymphatic system overall.

Learning Objectives

1. The participant will gain an understanding of recently documented changes seen in perivascular space following long duration spaceflight.
2. The participant will be introduced to an emerging topic in neuroscience: the glymphatic system.

[316] MARS MEDICAL SYSTEM MEDICAL HARDWARE CAPABILITIES SURVEY

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(Original Research)

INTRODUCTION: Mars missions will be significantly longer than current mission operations and challenges us to explore what will be needed to continue to optimize crew health. Medical hardware allows for health monitoring and treatment of many possible emergent, urgent,

ambulatory, and chronic conditions. There is not currently an understanding of medical hardware capability priorities for Mars missions. This study analyzes the perceived importance of medical capabilities for a Mars mission from survey data collected by XMIPT. **METHODS:** Thirty-six operational flight surgeons and physicians involved in exploration or operational activities were contacted to complete a survey on medical hardware capability needs for a Mars mission. Seventeen physicians completed the survey rating each of 43 medical hardware capabilities on a Likert scale of importance. Responses were converted to an importance score and ranked. Importance score averages were compared across subcategories of medical hardware capabilities and NASA-STD-3001 level of care definitions. **RESULTS:** No medical hardware capability was uniformly rated. Medical communications and basic monitoring were the highest rated subcategories. The medical hardware capabilities with the highest importance scores fell within medical capabilities of Level I or Level II per the NASA level of care definitions documented in NASA-STD 3001. **DISCUSSION:** Past experiences with current operational capabilities and past events may have informed physician responses. Respondents favored capabilities required for high likelihood, low consequence events over those required for low likelihood, high consequence events. The most highly rated capabilities are currently available on the ISS (International space station). Vision and ocular evaluation capabilities were highly rated potentially due to concerns regarding SANS (space associated neuro-ocular syndrome) as was ultrasound imaging capability. Importance score ratings serve to inform prioritization of capabilities and device development.

Learning Objectives

1. Understand the perceived importance of medical hardware capabilities for a Mars mission.
2. Analyze perceived medical hardware capability importance based upon type of capability and level of care of capability.

[317] SELECTION OF NEXT PRIORITY IMPACT MEDICAL CONDITIONS BASED ON AVAILABLE TERRESTRIAL AND SPACEFLIGHT DATA

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(Education - Program/Process Review)

BACKGROUND: As the era of exploration class missions begins, identification of medical conditions that may occur and require management becomes essential for the modeling of medical risk. To this end, NASA has developed IMPACT (Informing Mission Planning via Analysis of Complex Tradespaces), a suite of tools to assist in assessment of medical risk analysis. It has incorporated an initial list of the 120 conditions of highest concern, labeled the IMPACT condition list (ICL). This abstract describes a method for prioritizing the 92 conditions included on the Proposed Future Conditions List (PFCL) for inclusion in future iterations of the ICL. **OVERVIEW:** To construct the Prioritized Proposed Future Conditions List (P-PFCL), each condition on the PFCL was scored as "low," "medium," or "high" on each of four variables: incidence, likelihood of significant task impairment, diagnostic and treatment complexity, and treatment futility. Qualitative assessment using clinical judgement was utilized to score complexity, futility, and likelihood of impairment. Incidence was assessed quantitatively using spaceflight data and/or analog populations where available then assigned a score using established cutoffs. Logarithmic numerical values were assigned to each category label. A Prioritization Score was generated for each condition by taking the product of incidence and likelihood of task impairment (risk) divided by the product of complexity and futility (difficulty of care), with higher values corresponding to higher priority for future inclusion in the ICL. **DISCUSSION:** The described methods allow for the generation of a ranked P-PFCL to act as a decision support tool for selection of the next generation of modeled medical conditions. Some of the conditions

ranked highly on the P-PFCL include EVA-related upper and lower extremity sprain/strain, delirium, and hypertension, among others. While this effort does not attempt to quantify the absolute risk associated with each condition, it does attempt to semi-quantitatively estimate the risk of each condition relative to the other possible conditions. This tool in concert with subject matter expert opinion could optimize the future use of limited resources thereby producing a more accurate medical risk model, which will be essential to the upcoming exploration class missions.

Learning Objectives

1. Understand NASA's current approach to medical risk modeling for exploration class missions.
2. Learn a proposed method for prioritizing medical conditions for inclusion in medical risk models.

[318] BUILDING A ONE COUNTRY ONE LICENSURE FRAMEWORK: APPLICATIONS FOR THE FUTURE OF CANADIAN SPACE PHYSICIANS

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(Original Research)

Space medicine combines various medical specialties through providing care in the most extreme and resource-depleted environment known to humankind. With increased access and interest of the private sector, the space economy is forecasted to be a \$1 trillion industry by 2040. Increased access and utilization will require additional health-care support and legal frameworks. We reviewed the current Canadian medicolegal framework for the capability to adapt to this new demand. Currently, Canadian physicians are required to hold a license in each province they practice. As space medicine encompasses multiple medical specialties and its practice is beyond Canadian provincial jurisdictions, we identified a medicolegal gap in Canadian physicians' ability to legally provide healthcare in space. COVID-19 has demonstrated the challenges of the current Canadian paradigm of geographical licensing restrictions. These obstacles have caused detriment to healthcare provision more traditionally in remote communities, military medicine, and cross-jurisdictional telemedicine. By examining similarities and solutions deployed in these terrestrial situations, bi-directional translational licensing solutions may be found. Recommendations for an improved Canadian licensing framework targeting the provision of space medicine may also lead to improving the universality and access to healthcare for Canadians nationwide. These include, in brief, the development of a pan-jurisdictional medical license for clinicians certified in the RCPSC competency portfolio of aerospace medicine with all Canadian provinces and space as jurisdictional boundaries, and fast-track or portable licenses for space or ground-based physicians supporting aerospace missions.

Learning Objectives

1. Participants will learn about the current model of physician licensure in Canadian territories and provinces and its medicolegal gap in addressing Canadian physician licensing in space.
2. Participants will learn about challenges in the Canadian healthcare system presented by the provincial and territorial model of physician licensing and past solutions and proposals aimed at overcoming these challenges.
3. Participants will learn about how past Canadian medicolegal licensing solutions at addressing access to physicians can be applied to space medicine, including the proposal for a pan-jurisdictional competency-based license for space medicine.

[319] COMPREHENSIVE TRIALING OF MEDICATIONS PRIOR TO LONG DURATION SPACEFLIGHT

Haig Aintablian

University of California-Los Angeles, Glendale, CA, United States

(Education - Program/Process Review)

BACKGROUND: Medication selection and integration for next generation exploration-class missions is of the utmost importance in ensuring humanity's ability to reach distant planetary bodies. Each medication's breadth of use, dosing concentrations, adverse effects, and shelf-life must be heavily researched and scrutinized in order to provide the optimal, weight-efficient, and all encompassing medication architecture for long-duration interplanetary expeditions. Even with a robust medication infrastructure in place, the possibility of a medication complication is not addressed. The scenario of a crew-member requiring a medication during their expedition that they had not been exposed to terrestrially is almost certain to happen. What if they were subsequently found to have an adverse effect or allergic reaction to this medication millions of miles away from earth? **OVERVIEW:** We propose the following comprehensive, tiered, medication trial regimen implemented prior to long duration exploration-class missions in order to prevent this scenario.

1. Stimulant and Space Motion Sickness Combinations: Used to determine the most favored medication combination per crewmember for the prevention of space motion sickness as well as medication induced drowsiness, including 6 combinations of: promethazine, scopolamine, and meclizine with dextroamphetamine, or modafinil.
2. Common Allergen Exposures: Used to determine allergies to common medication classes that are of higher likelihood to cause allergic reactions and that are likely to be flown and used in long-duration spaceflight, including medications from each major class including: amoxicillin-clavulanate as a penicillin-class drug, Trimethoprim-Sulfamethoxazole as a sulfa-class drug, Doxycycline as a Tetracycline-class drug, Levetiracetam as an anticonvulsant category drug, and Aspirin as a NSAID category drug.
3. Procedural Exposures: A regimen used to determine adverse reactions to commonly used procedural components and medications, including exposure to latex, medical glue (cyanoacrylate-derivatives), medical tape (acrylate and methacrylate-derivatives), amide local anesthetic (Lidocaine) and ester local anesthetic (Tetracaine).

DISCUSSION: The goal of our proposed medication trial is to ensure an expected and safe response to medication classes and procedural materials that will be flown and used on these exploration class missions - an important aspect for successful long-duration space endeavors.

Learning Objectives

1. Understand the terrestrial epidemiology of medication reactions and their implications in long duration spaceflight.
2. Understand the clinically relevant medication-classes, including antibiotic and anesthetic classes, most attributed to adverse reactions.
3. Understand the current limitations in ground testing of medications prior to long duration spaceflight and the potential importance for terrestrial ground testing.

[320] FEASIBILITY OF TERRAFORMING MARS

Stephen Hobson

University of Vermont, Burlington, VT, United States

(Education - Tutorial/Review)

INTRODUCTION: For decades, science fiction books have envisioned terraforming planets into new worlds for humans to inhabit. More recently, space enthusiasts have begun to seriously advocate for humanity becoming a "multiplanetary species" by terraforming Mars. **TOPIC:** Terraforming Mars is not possible using present-day or near-future technology. Fully terraforming Mars would require the creation of a thicker atmosphere, warmer temperature, and breathable air. Mars is more than 100 degrees Fahrenheit colder on average than Earth, has less than 1% of the atmosphere of Earth, and the atmosphere that it *does* contain is 95% carbon dioxide, making it fatal for humans to breathe. Warming the planet and creating a thicker atmosphere would require releasing greenhouse gases like carbon dioxide from polar ice caps, surface regolith, and minerals in the crust. Even if all the available CO₂ were released, it would only make up about 3% of Earth's atmospheric pressure and still be toxic to breathe. If we accomplished the creation of an atmosphere and oceans

of liquid water on Mars, this would still not solve the lack of a magnetic field, weaker gravity, or the many health risks for humans traveling and surviving on the planet for long periods of time. None of the options for fully terraforming Mars are possible in the foreseeable future. Even if they were, the resources needed to dedicate to such projects would be better used to address environmental problems on Earth, our home planet that humanity evolved to live on. NASA and commercial space companies should focus their efforts in space on exploration, scientific discovery, and even commercial enterprise – *not* on terraforming Mars into Earth 2.0.

APPLICATION: It is possible for humans to maintain a long-term presence on Mars, but challenges to reproduction, growth, and development will exist if humans plan to “colonize” Mars for generations. Human space exploration of Mars should focus on first establishing permanent research stations with protective habitats and full life support systems. Next, humans can move toward “paraterraforming” with habitats, like domes, that are sealed and create livable conditions with pressure, temperature, and a breathable atmosphere. Paraterraforming may eventually lead to permanent human settlements on Mars, however, plans to fully terraform Mars should be abandoned until these more reasonable milestones are achieved or technological breakthroughs put the impossible within reach.

Learning Objectives

1. The audience will learn about current theories on how to terraform Mars to be more Earth-like.
2. The audience will learn why terraforming Mars is not possible using present-day or near-future technology.
3. The audience will learn about a more achievable vision for permanent research stations on Mars and paraterraforming.

[321] A LONG WAY TO MARS: A MULTIDIMENSIONAL ANALYSIS OF A 520-DAY SIMULATED MISSION

Galymzhan Issabekov

Kumagaya General Hospital, Kumagaya, Japan

(Original Research)

INTRODUCTION: Long-duration missions to Mars are being planned by public and private organizations in the 2030s, yet challenges to human health and performance remain. One major challenge is prolonged isolation and confinement. To this end, a comprehensive simulation was attempted to evaluate the potential impact of isolation and confinement stress on human health and performance, called the Mars500 project. The first Earth-based experiment investigated long-term health by isolating in a 550 m chamber healthy multinational crew for 520 days. As a result, there have been 25 publications associated with the Mars500 project. However, there has been a considerable lack of multidimensional analysis of these works. Thus, the objective of this study was to identify possible group- and individual-level correlations between data collected from various publications regarding the Mars500 project. **METHODS:** From June 3rd, 2010, to November 4th, 2011, six male subjects (three Russians, two Europeans, and one Chinese) with a median age of 31 years (range 27–38 years) lived under totally isolated and confined conditions in the Mars500 habitat located in Moscow, Russia. Physiological, psychological, proteomic, metabonomic, immune, microbiome, cardiovascular, and cognitive data were collected over 520 days. **RESULTS:** A total of 25 publication results came from the Mars500 project in the areas of physiology (n=8), psychology (n=9), biochemistry, immunology (n=4), and microbiology (n=4). Some biological functions were not significantly affected by isolation and confinement. However, significant changes in multiple data types were observed in association with the “landing period”. Specifically, a correlation between psychological and biochemical data were identified that included changes in plasma hormone level, sleep-wake alterations, body weight, skeletal muscle alternations, the circadian rhythm of cardiovascular control, cortical activity, gut microbiome composition, and serum metabolites. **DISCUSSION:** Given that most of the biological and human health variables remained stable or returned to baseline after a 520-day simulated mission, these data suggest that human health can be mostly sustained over this time

of isolation and confinement. These results highlight the importance of identifying biomarkers of characteristics predisposing prospective crewmembers during prolonged spaceflight confinement to inform crew selection, training, and individualized countermeasures.

Learning Objectives

1. The impact of chronic stress burden of 520-d isolation and confinement on the physiological, psychological, proteomic, metabonomic, immune, microbiome, cardiovascular, and cognitive response during the Mars500 simulated mission to Mars.
2. Identify possible group- and individual-level correlations between data and results collected from various 25 publications regarding the Mars500 project, which is the longest controlled human confinement study conducted to date.

Wednesday, 05/24/2023

2:00 PM

Grand Ballroom D-E

[S-59]: PANEL: A MOMENT OF FOCUS ON ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD)

Chair: Ryan Peirson

PANEL OVERVIEW: *This panel presents an update on the clinical aspects of ADHD and related aeromedical concerns. The panel will discuss various aspects including neuropsychological testing, clinical interview techniques, specific concerns in the aerospace environment, and new concepts in the natural history of the disorder. Members of the Neuropsychiatry branch of the USAF School of Aerospace Medicine's Aeromedical Consultation Service will highlight clinical experience as it relates to pilot applicants and trained air crew. Occupational and aeromedical assessments require a number considerations and the panel's aim is a practical discussion.*

[322] ATTENTION-DEFICIT/HYPERACTIVITY DISORDER: CLINICAL AND AEROMEDICAL PRACTICE GUIDELINES

Kevin Heacock

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Attention-deficit/hyperactivity disorder (ADHD) is characterized by a lifelong disturbance in the ability to marshal and sustain attention, modulate activity level, and moderate impulsive actions. The classic triad of ADHD symptoms includes inattention/distractibility, impulsivity, and hyperactivity. ADHD is common in society, USAF Airmen, and USAF flyers. How do we decide if ADHD will have an operational impact? **TOPIC:** When is psychostimulant use allowed in USAF aviators? Under what conditions? When is it forbidden? Can non-stimulant treatments be utilized to treat ADHD? Since ADHD is so common in our world and our aviation community, how do we undergo proper risk assessment, management, and mitigation strategies? **APPLICATION:** When evaluating ADHD in USAF flyers, under what conditions is it medically-qualifying (requiring no waiver), require a waiver, and when is it disqualifying? How do accommodations and treatment of ADHD impact aeromedical decisions? A discussion of problems noted with aeromedical summaries and waiver packages will be addressed. Although specific for Air Force pilots and aircrew evaluated at the Aeromedical Consultation Service, the underlying issues are common to aviators and waiver processes in all the military services and civilian organizations. **RESOURCES:** 1. American Psychiatric Association (Ed.). (2022). Diagnostic and statistical manual of mental disorders: DSM-5-TR (Fifth edition, text revision). American Psychiatric Association Publishing.

Learning Objectives

1. The participant will be able to understand the evaluation of ADHD in USAF flyers.
2. The audience will learn about how accommodations and treatment of ADHD impacts aeromedical decisions.

[323] ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD)-CLINICAL VARIABILITY AND NEW CONCEPTS FOR AN OLD FRIEND.

Ryan Peirson

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Although the diagnosis of ADHD is not particularly controversial in the mental health community, it continues to engender controversy and disagreement among clinicians more broadly. As the diagnosis increased in the past three decades, a larger number of individuals with a history of and treatment for ADHD are coming of age and seeking aeromedical waivers. With societal pressures and expectations changing, regulatory authorities face difficult challenges in addressing risk mitigation for a disorder with a broad spectrum of severity and clinical presentations. **TOPIC:** A neurodevelopmental disorder, ADHD is, by definition, a disorder that manifests in the developmental period and alters the remaining developmental trajectory. Older concepts estimated that perhaps half of individuals with known ADHD in childhood “grow out” of the disorder in adulthood. Newer data suggest a waxing/waning presentation for many. Further, the severity is also variable which may be attenuated by a number of factors including family support and intellectual capacity or made worse by comorbid conditions or the consequences of the very behaviors for which individuals are known to have greater risk—especially substance use and social issues. This makes aeromedical risk assessment particularly challenging especially when there is incentive to minimize or simply cope with symptoms due to the generally strict proscription against medical qualification. **APPLICATION:** ADHD is a prevalent condition among flying applicants and is potentially waiver-eligible in USAF aircrew. Notoriously difficult to evaluate, and difficult to monitor and mitigate, excellent evaluation and management have the potential acceptably mitigate for some, but not for others. This presentation will highlight these concepts and is primarily relevant to USAF flight surgeons but it also has utility for other military services and civilian flight medicine. **RESOURCES:** 1. American Psychiatric Association. *Diagnostic and statistical manual of mental disorders*, 5th edition. Arlington (VA): American Psychiatric Association; 2013:265-290. 2. Sibley M, Arnold L, Swanson J, et al. Variable patterns of remission from ADHD in the multimodal treatment study of ADHD. *Am J Psychiatry* 2022; 179:142-151. 3. Viscera S, Danielson M, Bitsko R, et al. Teens in the parent-report of health care provider diagnosed and medicated ADHD: United States, 2003-2011. *J Am Acad Child Adolesc Psychiatry* 2014; 53:34-46.

Learning Objectives

1. Participants will understand the data behind suggesting a waxing and waning presentation for many with ADHD.
2. Participants will understand the variability in the presentation of ADHD—especially how some are able to cope more than others.

[324] ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD) – CONTRIBUTIONS OF NEUROPSYCHOLOGICAL ASSESSMENT IN THE AVIATION POPULATION

Monica Malcein

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: ADHD is a neurodevelopmental disorder characterized by a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning. There is percentage of individuals who had symptoms of ADHD in childhood that have symptoms persist into adulthood. Characteristics of the disorder, to include impaired attention, cognitive inefficiency and impulsivity, can impact functioning and make it unsafe to perform aviation duties. Comprehensive assessment, to include a careful history and assessment of neurocognitive functioning, is important for diagnostic clarification and identification of functional limitations as they relate to flying. **TOPIC:** Neuropsychological assessment of individuals with a history of or concern for ADHD can provide useful

information regarding current cognitive functioning as part of the overall clinical assessment. In general, neuropsychological profiles of adults with ADHD shows weaknesses on measures of attention, information processing speed, executive functioning, and memory. More specifically, research has documented deficits that are most evident in attention, response inhibition, word generation, and memory. Such findings from neuropsychological evaluation can be helpful in the diagnostic process or in characterizing cognitive deficits associated with the diagnosis in the general population. It is well-established that aviators are a unique population with superior intellectual and cognitive abilities, and it is unclear whether those with a history of ADHD have a similar presentation on neuropsychological testing as those in the general population. There is concern that ADHD-related cognitive deficits may be easily overlooked in the those with higher levels of intellectual ability. A review of neuropsychological evaluation findings in those with a history of ADHD seen at the Aeromedical Consultation Service will explore the usefulness of neuropsychological testing data in this population. **APPLICATION:** ADHD is disqualifying for flying duties in the USAF, but a waiver may be considered for flying if stability can be documented. Neuropsychological features associated with ADHD have the potential to negatively impact functioning in the aviation environment and should be thoroughly assessed. This presentation will focus on the usefulness of neuropsychological assessment in aviators and will discuss findings from a series of evaluations conducted with pilots and other aircrew.

Learning Objectives

1. The audience will gain knowledge about the neuropsychological findings associated with adult ADHD.
2. Findings from neuropsychological assessment in aviators with a history of ADHD will contribute to understanding of this population.

[325] ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD) – HOW IS THIS RELEVANT IN AVIATION?

Terry Correll

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: The essential feature of attention-deficit/hyperactivity disorder (ADHD) is a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development.¹ **TOPIC:** Population surveys suggest that ADHD occurs worldwide in about 7.2% of children. In a cross-national meta-analysis, ADHD occurred in 2.5% of adults. Adults with ADHD show poorer occupational performance, attainment, attendance, and higher probability of unemployment, as well as elevated interpersonal conflict.¹ Many of these symptoms are common, but the diagnosis of ADHD is made when the symptoms interfere with school/work/relationships and activities of daily living. On average, individuals with ADHD obtain less schooling, have poorer vocational achievement, and have reduced intellectual scores than their peers, although there is great variability. In its severe form, the disorder is markedly impairing, affecting social, familial, and scholastic/occupational adjustment.¹ ADHD also commonly overlaps or coexists with other mental health conditions. **APPLICATION:** Features associated with ADHD in adults could have a negative impact in the aviation environment and could cause one to be found unfit for flying duties. This presentation will focus on the selection and retention of aviators as it relates to ADHD. A discussion of problems noted with aeromedical summaries and waiver packages will be addressed. Although specific for US Air Force pilots and aircrew evaluated at the Aeromedical Consultation Service, the underlying issues are common to aviators and waiver processes in all the military services and civilian organizations. **RESOURCES:** 1. American Psychiatric Association (Ed.). (2022). *Diagnostic and statistical manual of mental disorders: DSM-5-TR* (Fifth edition, text revision). American Psychiatric Association Publishing.

Learning Objectives

1. To understand the impact that ADHD has in the aviation community.
2. To discuss risk assessment, management, and mitigation for Air Force aviators and aircrew with ADHD.

Wednesday, 05/24/2023
Grand Chenier

2:00 PM

[S-60]: PANEL: SAFETY CENTERS YEAR-IN-REVIEW

Chair: Ajiri Ikede

PANEL OVERVIEW: This panel presents a review of recent aerospace safety data. Representatives from military and civil aerospace organizations will present summaries and analyses of recently collected safety data. Topics may include: cause factors including mechanical and human factors, identifiable safety trends, and updates on mitigation strategies for current risks. With certain types of accidents becoming rare events, the panel discussion is a unique opportunity to review the collective experiences of multiple safety programs and consider a variety of risk mitigation solutions.

[326] TRANSPORT CANADA: YEAR-IN-REVIEW

Tyler Brooks

Transport Canada, Ottawa, Ontario, Canada

(Original Research)

BACKGROUND: Transport Canada is the federal regulator responsible for policies and programs which promote safe, secure, efficient, and environmentally responsible transportation in Canada. This presentation will familiarize participants with the mission of the Civil Aviation Medicine (CAM) Branch of Transport Canada, and highlight topics of interest arising in over the past year. **OVERVIEW:** The mission of the CAM Branch of Transport Canada is to ensure aircrew and air traffic controllers are medically fit, to close gaps in scientific knowledge of Canadian aviation medicine, to promote health and safety in the field of aviation, and to prevent aircraft accidents due to medically related human factors. The CAM Branch will present an overview of notable civil aviation medicine issues encountered over the past year. **DISCUSSION:** Aviation medicine practices and policy respond not only to changes in medicine, but also to changes in society, politics, and global events. The CAM Branch of Transport Canada shares its experience responding to a variety of issues.

Learning Objectives

1. Understand the mission of the Civil Aviation Medicine Branch of Transport Canada
2. Understand Transport Canada's experience in responding to specific issues related to aviation medicine

[327] NAVAL AVIATION SAFETY: 2022 YEAR IN REVIEW

Robert Krause

Naval Safety Command, Norfolk, VA, United States

(Education - Program/Process Review)

BACKGROUND: The Naval Safety Command analyzes Navy and Marine Corps aviation safety investigation reports in order to identify mishap causal factors and recommend corrective actions. **OVERVIEW/METHODS:** All Class A flight mishaps involving US Navy and Marine Corps aircraft during fiscal year 2022 (FY 2022) were reviewed using the Human Factors Analysis and Classification System (HFACS). **RESULTS:** During FY 2022 there were multiple Class A Flight mishaps in the U.S. Navy and US Marine Corps. A review of Class A flight mishaps over the past 10 years demonstrated that human factors were the predominant causal factors. A review of current Physiological Episodes and Events in Naval Aviation will also be presented. **DISCUSSION:** HFACS is a useful tool in safety investigation analysis and assists in identifying causal factors to focus mitigation strategies to prevent future mishaps. Its standardization across the Department of Defense facilitates cross-analysis and shared efforts to prevent future mishaps.

Learning Objectives

1. Review the overall trend in US Navy and Marine Corps flight mishaps and the most common human factors identified as causal factors.
2. Identify the most common Human Factors Analysis and Classification System (HFACS) categories for Naval Aviation mishaps and review the trends of mishap HFACS causal factors over the last decade.
3. Become familiar with emerging topics of discussion at the Naval Safety Command related to aviation, including physiologic events.

[328] AIR FORCE AVIATION AND SPACE SAFETY: 2022 YEAR IN REVIEW

Andrew Metelko, Kevin Alford, Geoffrey Ewing, Denise Zona, Michael Armstrong

U.S. Air Force, Kirtland AFB, NM, United States

(Education - Program/Process Review)

BACKGROUND: The United States Air Force Safety Center's Human Factors experts support commanders and safety professionals Air Force wide by applying human factors (HF) expertise to identify, anticipate, analyze, manage and prevent human factors risk in Air Force operations and safety culture. **OVERVIEW/METHODS:** The Human Factors Division analyzed All Class A mishaps, manned/unmanned aviation mishaps, fatalities, CFIT/GLOC events, and the predominate HF identified in fiscal year 2022 mishap investigations. **RESULTS:** Overall USAF mishap trends were mixed in 2022 but supported a continued downward trajectory for fatal aviation mishaps. Commonly identified HFs stayed consistent across most categories. **DISCUSSION:** HF continues to contribute significantly to aviation mishaps representing a pivotal area for improvement in the goal to reduce mishaps. Future efforts should focus on improving consistency in identification and categorization of HFs in Air Force mishaps to support trend analysis and recommendations for improvement.

Learning Objectives

1. Review the overall trends in US Air Force aviation and space mishaps.
2. Identify the most common Human Factors Analysis and Classification System (HFACS) categories for USAF US Air Force mishaps.
3. Understand limitations human factors trend analysis and consider methods to improve human factors mishap recommendations to instill behavior changes that reduces mishap frequency and severity.

[329] UK MILITARY AVIATION SAFETY AND AIRCRAFT ACCIDENT INVESTIGATION: YEAR IN REVIEW

Matthew Lewis

RAF Centre of Aviation Medicine, Baldock, United Kingdom

(Education - Program/Process Review)

BACKGROUND: The purpose of this presentation is to identify the primary causal factors, survival and injury outcomes, and crew escape system performance findings from UK military aviation accidents. The analysis centred on both human and technical causal factors. Hazard trends were identified and compared with previous years' data. **OVERVIEW:** Aircraft accident data were obtained from military aircraft accident databases and the causal factors and injury outcomes were analysed. For the RAF the all-aircraft accident rate was 0.07 per 10,000 flying hours (FH), with one Class A (Category 5) mishap and no fatalities. The rates for RN accidents rate were 1.99 per 10000FH, with a rolling 10-year rate of 1.25 per 10000 FH. However, these data are skewed by ground incidences which did not involved aircraft losses. The injuries sustained by the aircrew ranged from minor cuts and abrasions through to major skeletal injuries. Where escape systems had been used these worked satisfactorily, although there were failures of the survival equipment which could have caused different outcomes had the aircraft losses occurred over water. These shortcomings were common to a number of aircraft platforms and also occurred on sea survival training as identified by Defence Air Safety Occurrence reporting and trend analyses. **CONCLUSION:** UK military accident rates have shown a gradual reduction over the past ten years with the largest reduction being

shown by fast jets. Human factors persist in being the major cause of aircraft accidents and in particular were responsible for the loss of an F35 Lightning II aircraft.

Learning Objectives

1. The audience will learn about the UK military's efforts to utilise aviation accident data to develop proactive intervention strategies to prevent future accidents in an effort to preserve human life and aircraft losses.
2. Understand the importance of how aircrew equipment design and function is critical to aircraft accident survival.

[330] ROYAL CANADIAN AIR FORCE FLIGHT SAFETY: YEAR IN REVIEW 2022

Ajiri Ikede

Canadian Armed Forces, Ottawa, Ontario, Canada

(Education - Program/Process Review)

MOTIVATION: The Commander of the Royal Canadian Air Force (RCAF) is appointed as the Airworthiness Authority for all aviation in the Canadian Armed Forces (CAF). The Director of Flight Safety (DFS) is appointed as the Airworthiness Investigative Authority for all flight safety occurrences with the goal of preventing accidental loss of aircraft and personnel. Contributory or causal human factors are identified using the Canadian Forces Human Factors Analysis and Classification System (CF-HFACS). Statistics and analysis from 2022 are discussed. **OVERVIEW:** Accidents and incidents from 2022 were reviewed to identify human factors which may have caused or contributed to these occurrences. The Self-Administered Interview (SAI) was adopted as the standard operating procedure for collecting witness statements in 2021 and continues to be of great utility. **SIGNIFICANCE:** Fatigue, culture and substances hazardous to aviation continue to be relevant hazards in the RCAF. DFS has helped to propel several risk mitigation initiatives specifically aimed these factors, including the implementation of the RCAF Fatigue Risk Management System, while facilitating the international distribution and use of SAI for accident investigations.

Learning Objectives

1. Understand the overall trends in RCAF flight occurrences in 2022.
2. Understand the effectiveness of the SAI in the collection of information from witnesses, especially when timely face-to-face interviewing is not possible.

[331] US ARMY AVIATION SAFETY: FY 2022 YEAR IN REVIEW

Luis Rivero, Sean O'Connell

U.S. Army, Fort Rucker, AL, United States

(Original Research)

INTRODUCTION: Discuss (FY) 2022 statistics and analysis for USA Class A aviation mishaps including Human Factors Analysis. **METHODS:** FY2022 data was obtained from the USA Combat Readiness Center database (ASMIS2.0) for Class A thru C manned aviation mishaps and reviewed for human factors as determined by the Safety Investigation Boards. **RESULTS:** In the manned aircraft category, Army aviation experienced 57 Class A - C manned aircraft Flight mishaps in FY22. This was a decrease from the 59 Class A-C Flight mishaps reported in FY21. The US Army experienced 4 Class A manned aviation Flight mishaps during FY22, 57% below the 7 Flight mishaps reported for FY21. The accident rate for Class A Flight mishaps (per 100,000 flying hours) was 0.50 in FY22, a 37% decrease from the 0.87 Class A record rate recorded in FY21. There were only two aviation mishap fatalities in FY22 compared to 13 in FY21. **DISCUSSION:** For the third year in a row, Army Aviation has remained below a rate of one mishap per 100,000 flying hours. This overall rate is the result of three years in a row of single digit Class A Mishaps (FY20 = 6, FY21 = 8, and FY22 = 8). The Army continued to maintain a Class A mishap rate below established norms during FY22. FY22's manned Class

A flight mishap rate was 0.50 per 100K flying hours, the sixth time in the last ten years the rate has been below the 1.0 mark and lower than the ten-year rate of 1.10. There were eight Class A mishaps (4 Flight; 1 Flight Related; 3 Aircraft Ground) reported in FY22 with approximately 803,683 hours flown. Human error continues to be the leading cause factor in Army Class A Flight mishaps.

Learning Objectives

1. With historically low Class A mishap rates, the Aviation Division at the USACRC has shifted its focus to Class C and below mishaps that account for 88% of the flight and flight related mishaps. We will discuss leading categories for Class A-C mishaps between FY16 and FY22.
2. We will discuss other areas of focus to reduce Class C and below mishaps, such as aviation ground events such as ground handling and servicing.
3. Discuss the primary cause factor in manned and unmanned aircraft mishaps.

Wednesday, 05/24/2023

Napoleon Ballroom C1-C2

2:00 PM

[S-61]: PANEL: RESIDENT IN AEROSPACE MEDICINE (RAM) GRAND ROUNDS III

Chair: Jonathan Elliot

Co-Chair: Albert Lee

PANEL OVERVIEW: Resident in Aerospace Medicine (RAM) Grand Rounds consists of 6 clinical case presentations. Each case is presented by current RAMs who will review the clinical case, diagnosis, treatment pathway and current policies from different agencies. The aviator's aeromedical disposition and waiver or special issuance outcome (if applicable) will be discussed. These unique case presentations describe clinical aviation medicine as well as policy updates for common medical and/or mental health conditions encountered in the practice of Aerospace Medicine.

[332] DOC, MY URINE IS BROWN

Jason Gordon

Naval Aerospace Medical Institute, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: This case describes novel exertional rhabdomyolysis provoked in the upper extremities of a man following an 18 minute series of concentric and eccentric upper body exercises. **BACKGROUND:** Exertional rhabdomyolysis is a potentially life threatening condition with high morbidity if left untreated. Exertion may be short and extreme muscle damage may still occur. Aviators and maintainers with limited time to exercise may opt for high intensity, short exercise sessions without an adequate adjustment or warm up period or adequate baseline hydration. Education of our aviation personnel on the risks associated with burst workouts is warranted to ensure adequate personnel availability and limit personal harm. **CASE PRESENTATION:** A 32-year-old right hand dominant man with unremarkable past medical history performed a workout of 120 pull ups and 120 dips in 18 minutes. His serum creatine kinase [CK] peaked at 238,000 units/liter (U/L) with gross edema of only his right forearm. He never experienced acute kidney injury and was able to maintain a glomerular filtration rate greater than 100 milliliters/minute following 10 liters of intravenous [IV] crystalloid therapy over 2 inpatient hospital days. One week after the initial workout his follow-up CK was 25,000 U/L and he had no evidence of morbidity at the end of one month. **DISCUSSION:** First described in war zones from crush injuries, rhabdomyolysis is a syndrome resulting from damage to the muscle sarcolemma. It may also occur from non-traumatic exertion in a healthy, fit person who has the mental drive and physical ability to push themself

beyond a pain threshold normally signifying muscle fatigue. The triad of myoglobinuria, myalgias and fatigue may be present but is rarely seen. Treatment of exertional rhabdomyolysis via multiple crystalloid boluses alone without dialysis, alkalinization of urine, or complex monitoring techniques is an acceptable first line treatment. Theoretical hyperchloremic metabolic acidosis does not appear to occur in previously healthy patients. With rapid evaluation and treatment of a previously healthy patient with no underlying risk factors who presents with elevated CK secondary to exertion, the prognosis is good and the diagnosis should not necessarily be cause for alarm.

Learning Objectives

1. The audience will learn about the potential risks associated with short burst exercise regimens common in aviation personnel.
2. The audience will learn about the treatment of exertional rhabdomyolysis and expected lab abnormalities.

[333] CORNEAL DEGENERATION IN A PILOT APPLICANT

Joelle Thorgrimson¹, David Hessert²

¹Royal Canadian Air Force, Pensacola, FL, United States; ²Naval Aerospace Medicine Institute, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: Corneal degeneration in a pilot applicant was eventually diagnosed in a complex ocular case resulting in disqualification. **BACKGROUND:** This unique case report illustrates the importance of ocular history disclosure and photo documentation of ophthalmologic pathology when waivers are granted. **CASE PRESENTATION:** Gelatinous drop like corneal dystrophy was initially diagnosed in a pilot applicant who previously had an approved waiver for a corneal scar. Following further information disclosure, this pathology was determined to be post-operative changes from previous Salzmann's nodule removal. **DISCUSSION:** Corneal dystrophy and degeneration are disqualifying conditions for military pilot applicants. Ocular history must be shared by applicants for appropriate diagnosis. Photo documentation should be completed and reviewed when waivers are granted.

Learning Objectives

1. The participant will be able to understand the decision-making process of ophthalmologic medical waivers.
2. The audience will learn about the pathophysiology for corneal dystrophy and degeneration as it relates to compatibility with flight crew operations.

[334] SEVERE ALTITUDE ILLNESS AT 12,000 FT IN MILITARY SERVICE MEMBER

John Solak, Yiwei Jiao

U.S. Army Department of Aviation Medicine, Fort Rucker, AL, United States

(Education - Case Study)

INTRODUCTION: This case report describes a military service member who experienced severe altitude illness at 12,000 ft while participating as a research volunteer. **BACKGROUND:** The U.S. military conducts operations in diverse geographical locations across the globe, thus altitude illness can pose significant operational challenges. Acute mountain sickness (AMS) is the most common form, and its symptoms can be debilitating, while the less common high altitude pulmonary edema (HAPE) and high-altitude cerebral edema (HACE) can be life threatening. Currently, there are no reliable methods to predict likelihood of severe altitude illness. Therefore, early recognition of its signs and symptoms and prompt interventions are paramount in preventing sequelae. **CASE PRESENTATION:** A 19-yr old healthy, physically fit with no significant medical history volunteered in an altitude illness related research. He had no prior high-altitude experience. He and his cohort of volunteers ascended from 3,981 ft (1,213 m) to 9,321 ft (2,841 m) over seven hours by vehicle, then ascended to 12,000 ft (3,657 m) over two hours by hiking while carrying 15% of body weight. He started experiencing symptoms of headache, tachycardia, shortness of breath, within several hours of arriving at 12,000 ft that gradually worsened over the

next day. On the morning of the third day at altitude, he started exhibiting dry cough, chest tightness, and neurological symptoms including ataxia, mild confusion, and mild slur in speech. Exam showed crackles in the lungs. He was immediately treated with supplemental oxygen and descended by vehicle to approximately 7,000 ft to be evaluated at an emergency department. Chest x-ray confirmed presence of pulmonary edema and brain CT was inconclusive. He successfully recovered without significant long-term sequelae. **DISCUSSION:** This case highlights the acute and unpredictable nature of severe altitude illness in a healthy individual without prior high-altitude experience as well as the importance of early recognition and intervention to prevent long term sequelae or death. Proper logistical and operational planning in preparation for the treatment of severe altitude illness in austere environments and possible hostile enemy territory is also a major consideration in this case.

Learning Objectives

1. Recognition of the signs and symptoms of severe altitude illness.
2. Operational considerations of severe acute mountain sickness in austere and possible hostile environments.
3. Treatment options of severe acute mountain sickness.

[335] A CASE OF ACUTE MYOCARDITIS MIMICKING MYOCARDIAL INFARCTION WITH NORMAL CORONARIES

Andrew Glenn, Heung Noh

Department of Aviation Medicine, Fort Rucker, AL, United States

(Education - Case Study)

INTRODUCTION: This is a case of a viral myocarditis mimicking a myocardial infarction in an Army flight student. **BACKGROUND:** Myocarditis is the inflammation of the heart muscle with variable clinical presentations that require close attention of a flight surgeon. While most commonly caused by a viral illness, myocarditis is known to have other etiologies such as bacterial infection, sarcoidosis, and systemic lupus erythematosus among others. Roughly half of the cases are due to undetermined etiology. The onset can be acute versus chronic, or focal versus diffuse. For aviation safety, myocarditis must be carefully evaluated, and risk stratified after resolution prior to performing flying duties. **CASE PRESENTATION:** A 25-year-old National Guardsman in Army flight school presented to an emergency department (ED) with complaint of severe chest pain, left arm pain, diaphoresis and shortness of breath. The symptoms woke him up from sleep at 4 a.m. but resolved without intervention. Same symptoms arose again while driving home from work but this time persistent, prompting him to report to an ED. Patient reported congestion and flu-like symptoms for the past month and two nights with night sweats prior to the ED presentation. Serial troponin level per ED chest pain protocol showed rise from 11,000 ng/mL to greater than 25,000 ng/mL without EKG changes. Cath lab evaluation for suspected NSTEMI demonstrated normal coronary vessels with some apical akinesia. Stress test was unremarkable, and the echocardiogram showed borderline but normal cardiac motion. His symptoms in hospital improved with Imdur and morphine, and post-discharge Holter monitor and cardiac MRI were both unremarkable. Upon review of the cardiac tests, viral myocarditis was determined to be the leading diagnosis. With a favorable prognosis, the patient later graduated from flight school with his duties were limited to simulator only. Final month of flight training is exclusively done on simulators for all flight students. Meanwhile he completed his further cardiology follow up. **DISCUSSION:** Viral Myocarditis is a temporary medical condition that is not compatible with flight but has a favorable prognosis for recovery and return to flight duties. Flight duties usually resume 6 months after the initial episode of Viral Myocarditis with no residual symptoms and negative follow up testing to include EKG, stress test, echo and cardiac MRI.

Learning Objectives

1. The audience will learn about the presentation and diagnosis of Viral Myocarditis.
2. The audience will learn about the aeromedical implications and flight considerations of patients with Viral Myocarditis.

[336] IT ISN'T A DOLPHIN, IT'S A ZEBRA

Katherine Cortez

U.S. Navy, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: A 26-year-old male presented to his annual flight physical reporting recent worsening of chronic folliculitis. This case study reviews the relevant workup as well as the ultimate relevant diagnosis and findings. **BACKGROUND:** Primary Cutaneous Follicular Center Lymphoma (PCFCL) is a rare B-cell form of Non-Hodgkin's Lymphomas, with an incidence rate at around 1 per 1,000,000 per year in Western countries. A diagnosis of middle age, the disease is exceedingly rare in the youthful military-aged population. PCFCL follows an indolent course, sometimes present for decades before diagnosis, and has an extracutaneous dissemination rate of approximately 10%. For overall prognosis, PCFCL is considered treatable but not curable. With treatment the 5-year survival rate is excellent, at >95%. The recurrence varies based on treatment; the lowest recurrence is seen with radiation, approximately 30% at 10 year. PCFCL and other indolent lymphomas present a complex aeromedical decision pathway, taking into account considerations of complications of treatment, frequent specialist follow ups, high likelihood of recurrence, and overall general lack of robust data on this rare disease.

CASE PRESENTATION: This student naval aviator had a 6-year diagnosis of recurrent folliculitis on his anterior trapezius that was historically treated conservatively. On his most recent flight physical, he reported several 'red spots' on his torso and face that had been waxing and waning for several years and had recently been worsening. After biopsy, he was diagnosed and treated for Primary Cutaneous Follicle Center Lymphoma.

DISCUSSION: This case will discuss medical issues in line with this diagnosis as well as the pertinent aeromedical considerations surrounding the case. It is intended for Aerospace Medicine Residents and Flight Surgeons to aid in determination of flight duty eligibility as well as general military duty eligibility.

Learning Objectives

1. Participants will be able to develop a cursory differential list and initial evaluation plan for chronic folliculitis-like skin complaints.
2. Participants will gain knowledge of the aeromedical implications of indolent cutaneous lymphomas.

[337] HYPOCAPNIA WITHOUT PANIC RESULTING IN PHYSIOLOGIC SYMPTOMSChristopher Rock¹, Evan Knock²¹Naval Aerospace Medical Institute, Pensacola, FL, United States; ²Naval Training Air Wing 6, Pensacola, FL, United States*(Education - Case Study)*

INTRODUCTION: We present a case involving aircrew aboard a T-6A training aircraft who experienced a suspected apapnic physiologic event which we believe was caused by oscillating oxygen concentrations from the on-board oxygen generation system (OBOGS) resulting in a physiologic response of hyper, then hypoventilation. **BACKGROUND:** The Navy's definition of a physiological episode (PE) is when a pilot experiences a loss in performance related to insufficient oxygen, depressurization, or other factors during flight. Hypocapnia (hypocarbica) is a recognized, less common etiology associated with hyperventilation conventionally correlated to episodes of panic, severe anxiety, or stress. **CASE PRESENTATION:** Instructor Pilot (IP) and Student NFO (SNFO) were on a day instrument flight from NAS Pensacola. The aircraft departed at 0824. There was a steady and continuous climb, during which all advisory/caution/warning lights were consistent with normal operations. At approximately 0837, the aircraft reached 23,000 feet. Two minutes later (0839), the OBOGS FAIL warning light illuminated. The IP silenced the warning light and, within 5 seconds, began to experience symptoms of lethargy, and dizziness. At this time, the SNFO was not experiencing symptoms. While the IP and SNFO initiated procedures for physiological symptoms, the OBOGS FAIL light illuminated a second time at 0840, and SNFO noted symptoms. Both aircrew switched to emergency bottled oxygen

and began immediate descent. Once below 10,000, MSL, both aircrew dropped their masks and noted an immediate reduction in symptoms. **DISCUSSION:** OBOGS data analyzed from this flight showed that the oxygen composition control algorithm was delivering wide concentration swings at the outlet of the concentrator. Even with the oscillations, OBOGS oxygen concentration remained above physiological minimums, making classic hypoxic hypoxia unlikely. A maintenance investigation ruled out the possibility of contamination resulting in histotoxic hypoxia. The patients had no factors to suspect anemic hypoxia. We propose the most likely explanation to be hypocapnia.

Learning Objectives

1. Define what constitutes a physiologic event in the context of aerospace medicine, and the various causal factors known to contribute to physiologic events.
2. Describe the pathophysiology of hyperventilation-induced hypocapnia, and how the proposed oscillating oxygen concentration mechanism could lead to hypocapnia.

Wednesday, 05/24/2023**2:00 PM****Napoleon Ballroom D1-D2****[S-62]: PANEL: ADVANCES IN AEROSPACE MEDICINE IN IBEROAMERICA***Sponsored by Iberoamerican Association of Aerospace Medicine***Chair: Rocio Garzon****Co-Chair: Angela Gomez**

PANEL OVERVIEW: This session is given in Spanish language with English slides. This session offers a space to share the advances made in Iberoamerica in different aspects of aerospace medicine. On this occasion, accident investigation topics, from Spain, will be followed by physiology research (Colombia), and clinical aspects will be presented (Venezuela).

[338] HUMAN FACTORS INVOLVED IN THE FIRST A400M AIRCRAFT ACCIDENT

Beatriz Puente

Spanish Air Force Institute of Aviation Medicine, Madrid, Spain

(Education - Case Study)

INTRODUCTION: The A400M is a European cutting-edge transport aircraft for military use designed as a tactical airlifter with strategic capabilities to replace older transport aircraft. **BACKGROUND:** The A400M is equipped with four turboprop engines, manufactured by Airbus Military S.L. and operated by seven European Armed Forces and three other countries. The mishap aircraft was undergoing its final industrial operational tests, which are conducted prior to the aircraft's delivery to the end customer. **CASE PRESENTATION:** The flight took place on 9 May 2015. The accident occurred during the first production acceptance flight. The crew consisted of six ADS employees, four of them were killed, and the other two were seriously injured. All the procedures carried out on the day of the accident until the moment of take-off were conducted within the usual parameters associated with this type of flight. During the take-off phase and shortly after rotation, the crew received various warnings pertaining to the degraded operation of engines 1, 2, and 3. This degraded operation froze the power of engines 1, 2, and 3 at take-off (maximum) thrust. The crew was unable to change engine power and had no engine information in the cockpit. The crew's subsequent actions to adjust the speed and altitude parameters ended up leaving the aircraft with the thrust for engines 1, 2, and 3 frozen at flight idle. The operation of engine 4 was not affected. Due to the loss of power, the aircraft was unable to maintain altitude; as a result, three and a half minutes after initiating the take-off run, it impacted the ground. The aircraft was destroyed. **DISCUSSION:** Human Factors were

analyzed during the investigation and will be discussed during the presentation. These include not only medical and pathological information but also situational awareness, complexity, automation, stress and performance, crew resource management, decision-making, man-machine interface, and training. Some of these factors were considered probable causes and some contributing factors, leading to several recommendations. The analysis was based on the taxonomy of the Human Factors Analysis and Classification System (HFACS).

Learning Objectives

1. The participant will be able to understand the capital importance of human factors analysis in aircraft accident investigation.
2. The audience will learn about the results of a thorough investigation of the accident of a modern aircraft.

[339] ALTITUDE-HIKING PHYSIOLOGICAL EFFECTS IN AEROSPACE MEDICINE RESIDENTS AT THE CHINGAZA NATIONAL PARK, BOGOTA, COLOMBIA

Adriana Zuluaga Serna¹, Laura Maria Pineda Jimenez¹, Diego Malpica², Diego Manuel Garcia Morales³, Gustavo Adolfo Celis-Ceballos¹

¹Universidad Nacional de Colombia, Bogota, Colombia; ²Colombian Air Force, Bogota, Colombia; ³Embry-Riddle Aeronautical University, Daytona, FL, United States

(Original Research)

INTRODUCTION: Physiology training is key for crews, also for aerospace medicine specialists. Aerospace Medicine Residents (RAMS) take advantage from physiology training campaigns both as subjects and researchers. A group of RAMS based at 2640 meters above sea level (MASL) were exposed to a high-altitude hiking exercise, while recording various physiological variables in order to understand their own reactions to high altitude exercise. **METHODS:** Eight healthy RAMS were exposed to a hike of 1.62 km with a total change of altitude of 360 m up to 3700 MASL. They wore a Polar V800 and a H7 chest band to record RR. Data was exported to Kubios® standard free version 3.5 to analyze heart rate variability. Records were exported to Microsoft Excel® 2016. Descriptive, repeated measurements ANOVA were used to examine within-subjects differences. **RESULTS:** Age range was 27-40 (mean: 31 years old, SD 4.46) and 6 (75%) were females. Most RAMS (75%) had a normal body mass index, 1 (12.5%) was underweight and an equal portion was overweight. Lifestyle was reported as sedentary, for 50% of participants. The average time for ascent was 100min, the group spent 70min at the top of the mountain, and 80min for descent. Stress-related physiological variables such as mean heart rate and mean interval RR (MeanHR, MeanRR) showed mirrored behavior throughout the ascent, summit and descent, respectively, as recorded means with their 95% confidence interval indicate: MeanHR: 149.7 (139.6-159.8); 112.1 (96.8-127.4); 129.6 (117.4-141.7). MeanRR was 403 ms (373.8-432.2), 547 ms (472.8 to 622.6), 468 ms (422.9-513.2). Also, calculated stress index and Sympathetic Nervous System (SNS) showed similar behavior throughout the ascent, summit and descent, respectively: Calculated stress index recorded 21.4 (12.8-30.0); 15.1 (6.8-23.3); 18.9 (9.9-27.9) and, SNS 8.7 (6.7-10.7); 4.2 (1.5-7.0); 6.4 (4.1-8.7). **DISCUSSION:** A middle aged, female-predominant population of healthy RAMs were exposed to a high-altitude hike, showing expected physiological traits of acclimatization to hypobaric hypoxia. This acute exposure to altitude during a physically demanding activity was a successful approach to extreme physiology assessment both from study-subject and researcher perspective.

Learning Objectives

1. The participant will be able to understand the importance of conducting real-world scenarios to perform research as part of the residency program in aerospace medicine.
2. The participants will learn about the integration between the theoretical foundations of high-altitude physiology and the practical implications for residents in-training

[340] PREVALENCE OF DECOMPRESSION SICKNESS DURING HYPOBARIC CHAMBER TRAINING AT THE COLOMBIAN AIR FORCE, 2010-2020

Gustavo Adolfo Celis¹, Sonia Jaimes¹, Diego Malpica¹, Laura Maria Pineda Jimenez², Adriana Zuluaga S², Diego Manuel Garcia Morales³

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(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 of decompression sickness during hypobaric chamber training in the Colombian Air Force (COLAF) from 2010 to 2020. **METHODS:** Retrospective observational study on aircrews undergoing hypobaric chamber training at the Aerospace Medicine Center COLAF in Bogota D.C, Colombia, who were diagnosed with decompression sickness type I or II by the Aerospace Medicine service and the hypobaric chamber medical director. **RESULTS:** 6,745 crewmembers underwent hypobaric chamber training, 54 cases were included in the study due to signs and symptoms of decompression sickness (DCS), mostly men 35 (64.81%), ages from 21 to 44 years (median 30 years), the main specialties were nurses 19 (35.18%), pilots 14 (25.92%), flight technicians 7 (12.96%) and physicians 5 (9.25%); 34 (62.96%) were instructors or internal observers, the rest were students. 45 aircrews (83.33%) presented type I DCS, the main symptoms were joint pain in the upper limbs 19 (35.18%), joint pain in the lower limbs 18 (33.33%) and headache 6 (11.11%). Finally, the aircrews with type II DCS were 9 (16.66%). Regarding treatment, all patients required management with oxygen 100% and, all crewmembers with type II DCS and also three crewmembers with type I DCS, required hyperbaric oxygen treatment. The total prevalence of decompression sickness was 0.8%. **DISCUSSION:** The prevalence of decompression sickness during and after hypobaric chamber training is similar to what is reported in the literature, suggesting that a pre-chamber medical check and the period of denitrogenation, can help to reduce the risk.

Learning Objectives

1. The participants will be able to compare the frequency of decompression sickness during hypobaric hypoxia training in the Colombian Air Force with the published literature.
2. The audience will be able to go over the most frequent symptoms of sub-atmospheric decompression sickness during or after hypobaric hypoxia training in the Colombian Air Force aircrews.

[341] USE OF PCSK-9 INHIBITORS IN THE MANAGEMENT OF HOMOZYGOUS HYPERCHOLESTEROLEMIA IN COMMERCIAL PILOTS IN LATIN AMERICA. ¿ IS ALLOWED ?

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(Original Research)

The objective of the study is to know the number of commercial pilots diagnosed with familial dyslipidemia, determining the number of homozygous familial hypercholesterolemia in commercial pilots and identify possible aeromedical restrictions in this special population. Since studies have shown that patients with spontaneous functional PCSK9 deficiency have reduced LDL-cholesterol (LDL-C) concentration and increased long-term cardiovascular risk, PCSK9 (proprotein convertase subtilisin/kexin type 9), which is an enzyme that intervenes in the degradation of LDL receptors in the hepatocyte, in such a way that its blockade reduces said degradation, which ensures that the receptors are in continuous activity, allowing to increase the uptake and removal of LDL particles from the liver. plasma with consequent reduction in its plasma concentrations. **MATERIALS AND METHODS:** This is a retrospective

descriptive study, carried out in the period from June 2020 to June 2022 with a population from Argentina, Chile, Brazil, Colombia, the United States, Guatemala, Mexico, Panama and Venezuela. It was carried out through the analysis of the results of levels of Total Cholesterol, LDL, HDL of the selected population. The total population was 1,080, with an average age between 39 and 63 years of age. **CONCLUSIONS:** Using the data obtained, the prevalence of familial dyslipidemia between commercial pilots with established coronary disease and those in which it has not been diagnosed is established. Obesity and hypertension were identified as risk factors, although they are not enough to predict the risk. 110 users started PCSK9 inhibitors, improving LDL levels for 2 to 3 months, A total of 11 people from the initial population decided not to continue with this research ICAO and FAA in their medical regulations still do not mention the use of these inhibitors.

Learning Objectives

1. The objective of the study is to know the number of commercial pilots diagnosed with familial dyslipidemia.
2. Calculate people who started treatment with statins • Know how much these PCSK9.

[342] MEDICAL LEAVES OF AEROMEDICAL CERTIFICATE HOLDERS IN COLOMBIA: 2017 – 2022

Johana Giraldo¹, Brian Andres Ramirez², Maria Angelita Salamanca¹, Alexandra Mejia¹, Patricia Barrientos¹, Diego Garcia²
¹Aerocivil - Civil Aviation Authority of Colombia, Bogota, Colombia; ²National University of Colombia, Bogota, Colombia

(Original Research)

INTRODUCTION: Health affectations to aeromedical certificate holders is a key element for aviation safety given their safety-critical role. This study aims to describe medical leaves in this population, for gaining a general perspective of recurrent diagnosis, and for estimating associations between change of aeromedical certificate status and type of diagnosis. **METHODS:** This is an observational, cross-sectional study design gathering reports of sick leaves between 2017 and 2022, from certificate holders to the Colombia Civil Authority (CAA). Cumulative frequency distribution informed relations between the nature of the sick leave and its impact on the status of the medical certificate. **RESULTS:** 2331 result were processed, median age of the reporting personnel was 38 (IQR: 32 - 44), 56% were male. Most of them (49%) hold a 2nd class certificate, 42% hold a 1st class and 8.2% hold a 3rd class. Half (50.1%) of the medical leaves lasted less than 20 days. Major diagnostic categories reported during this period were respiratory diseases (47.4%), and musculoskeletal disorders (27.1%). Status of aeromedical certificate was affected by diagnoses in 406 cases (17% of reported total cases), 218 certificate holders went back to normal flight operations without restrictions on their certificate (9.3%), 123 are still deferred (5.2%), 17 of them (0.7%) received a special issuance certification, and 48 (2.05%) certificate holders were declared unfit. An observation by diagnostic-related groups revealed that 100% of psychiatric conditions reported derived in affected certificate status, while 72.9% of cardiovascular diagnosis, 71.4% of nervous system, 29.2% of urinary/reproductive, and 27.2 % of eye/ear-nose-throat conditions ended up affecting certificate status. **DISCUSSION:** Our observations demonstrate that most medical leaves reports in Colombia did not affect the status of the aeromedical certificate of those reporting, this mostly since aeromedical decision are made on an individual basis. Nonetheless, certain diagnoses are more prone to affect safety-critical human performance, thus more certificate holders with those conditions saw they medical certificate affected while individual assessment was performed. There was an evident surge of respiratory diagnosis reports after the 2020 period, findings easily relatable to the COVID-19 pandemic.

Learning Objectives

1. The audience will be informed about the distribution of medical leaves in Colombian certificate holders during the last six years.

2. Attendants will learn about how aeromedical certificate status was impacted by different major diagnostic categories of reported medical leaves.

Wednesday, 05/24/2023
Napoleon C3

2:00 PM

[S-63]: SLIDES: SPACE MEDICINE TO SCALE

Chair: John Allen

[343] EFFECT OF DEEP-SPACE TIME DELAY AND TEXT COMMUNICATIONS ON TELE-SURGICAL GUIDANCE

Chelsea Spencer¹, Scott Stegeman¹, Margaret Sui¹, Kristina Kramer¹, Dana Levin², Kathleen Mosier³, Ute Fischer⁴, Tovy Kamine¹

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(Original Research)

INTRODUCTION: It is possible that an astronaut on a long duration space flight will suffer a surgical emergency. As current plans do not involve sending someone with significant surgical training on long duration spaceflight, any surgical procedure will likely require remote telementoring. Space flight beyond the Earth-Moon system will involve significant time delay and text-only communication. Using simulation, we assessed feasibility of textual communications with significant time delay to guide remote appendectomy. **METHODS:** A laparoscopic simulator (Symbionix LAP Mentor III) was used to simulate a patient presenting with appendicitis, equipped to perform all necessary steps of laparoscopic appendectomy. Emergency medicine physicians (EMP) were guided by a board-certified general surgeon (GS) through an appendectomy both bedside and remotely using delayed textual communications. Each text message was sent with a 3.5 minute one way delay. Procedural efficiency characteristics were obtained and compared. Each EMP and GS completed the NASA Task Load Index (TLX) following appendectomy. GS also completed simulated appendectomy as a control. **RESULTS:** Twelve EMPs underwent bedside and remotely guided appendectomy, 6 in each group. Average appendectomy time by EMPs with bedside guidance vs. GS control was 10:25 min vs. 04:44 min (p=0.012). Remotely guided appendectomy averaged 40:44 min (p=0.003 compared to bedside). For right hand economy of motion, bedside vs. remote guidance was 2.78 cm/sec vs. 04.72 cm/sec (p=0.002). Average number of texts sent for remote guidance was 6.67, contributing an average of 23:20 min of wait time. Analysis of TLX data reveal no difference in demand between bedside and remote guidance. **DISCUSSION:** Bedside guided appendectomy required less time and was more efficient compared to remotely guided. Remote guidance of appendectomy is possible, however time delay associated with each text using a 03:30 delay resulted in an average 23:20 difference, which may translate to 02:44:08, or approximately 35 times longer than the GS control if using the 22:00 delay in communication to Mars. This increase in time requirement will require significantly increased amounts of disposables such as IVF and anesthesia supplies in a weight limited environment. Additional study is needed to assess other components of operative intervention and patient outcome.

Learning Objectives

1. The listener will understand the feasibility of remote procedural guidance with a significant time delay.
2. The listener will understand the where the task load burden falls with telementoring with significant time delay.

[344] TRANSCRIPTOMIC RESPONSE OF BIOENGINEERED HUMAN CARTILAGE TO PARABOLIC FLIGHT MICROGRAVITY IS SEX-DEPENDENT

Shankar Jha¹, Amira Aissiou¹, Kirtan Dhunoo¹, Hilda Ma², David Li¹, Rahul Ravin¹, Melanie Kunze¹, Kinston Wong¹, Adetola Adesida¹

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(Original Research)

INTRODUCTION: Microgravity induces osteoarthritic-like alterations at the transcriptomic levels in meniscal cartilages of rodents. However, little is known about the effects of microgravity on the transcriptome of tissue-engineered human cartilage cells. Furthermore, women have a worse prognosis with osteoarthritis than men and this is not well understood. We assessed the transcriptome response of engineered human cartilage tissue to short exposure to microgravity. We also assessed for sex specific molecular changes in the cartilage tissue after exposure to microgravity. We hypothesize that the transcriptome profile of engineered human cartilage will respond to short-term microgravity via parabolic flight and these changes will be sex specific. **METHODS:** Human bone marrow aspirates from 3 male and 3 female age matched donors were collected from the University of Alberta (U of A) Hospital. The U of A Health Research Ethics Board waived the need for consent of donors, as specimens were intended for discard post-surgery. Mesenchymal stem cells were isolated from these aspirates and expanded in an incubator for 7 days. Next, these cells underwent in vitro chondrogenic differentiation in collagen scaffolds for 21 days. The parabolic flight was conducted in the Falcon 20 at the National Research Council of Canada. Our samples cycled through 11 parabolas on the flight, exposing them to approximately 140 seconds of microgravity. After levelling-off, the cartilage was terminated in RNAlater. Post experiment analysis included RT-qPCR and whole transcriptome next generation sequencing. **RESULTS:** We observed 30 differentially expressed genes of human cartilage tissue in response to short term exposure to microgravity ($p < 0.05$). Furthermore, 94 male specific genes and 74 female specific genes were expressed in response to microgravity. **DISCUSSION:** Our research shows microgravity specific molecular changes in human bioengineered cartilage are sex specific. This has important implications including in the identification of drug targetable pathways and development of countermeasure technologies for long duration spaceflight. This research also helps elucidate the sex specific differences in the pathology of human cartilage tissue.

Learning Objectives

1. Understand the molecular changes that occur in bioengineered cartilage tissue exposed to short term microgravity.
2. Appreciate the clinical and long term space travel implications of this research.

[345] ESTABLISHMENT OF THE DEPARTMENT OF DEFENSE CLINICAL AND OPERATIONAL SPACE MEDICINE INNOVATION CONSORTIUM (COSMIC)

Craig Nowadly¹, David Burch², James McEachen³

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(Education - Program/Process Review)

BACKGROUND: Vertical take-off and vertical landing (VTVL) commercial spacecraft may provide the Department of Defense (DOD) rapid, global, point-to-point transit capability with unprecedented speed and ability to overfly contested airspace. The DOD is actively cultivating commercial spaceflight partnerships with US Transportation Command. Furthermore, the United States Air Force (USAF) has already established the Vanguard Rocket Cargo Program, assessing the feasibility of using commercial launch platforms for rapid movement of military cargo. The National Aeronautics and Space Administration (NASA) is the global leader in space medicine, with extensive space medicine research and

operational capability. However, DOD spaceflight will have a fundamentally different mission than NASA, utilizing kinetic, unregulated, suborbital, short-duration, VTVL flights. DOD personnel require different training, health screening, qualifications and mission risks than NASA. It is clear that the DOD will have different space medicine research objectives compared to NASA. **OVERVIEW:** In order to customize a DOD-specific space medicine research program in a systemic and logical fashion, we established the Clinical and Operational Space Medicine Innovation Consortium (COSMIC), a dedicated, clinically focused, space research presence within the 59th Medical Wing (MDW) En-route Care Research Center (ECRC) in close partnership with the 711th Human Performance Wing (HPW). **DISCUSSION:** With rapid advancements in engineering capability in commercial spaceflight, the goal of COSMIC is to advance DOD-specific space medicine research priorities that may not directly overlap with NASA or civilian spaceflight research gaps. By building a consortium led by the 59th MDW and 711th HPW, we will be able to leverage engineering capability, animal research laboratories, and human clinical research at both institutions. In the coming years, COSMIC will focus on feasibility studies involving engineering, animal, and human research. The long-term objective of COSMIC is to curate a permanent DOD-specific space medicine research capability, in partnership with other DOD, civilian, and international partners, to help inform DOD operational decision makers in the space medicine environment.

Learning Objectives

1. Introduce the purpose and vision of the DOD Clinical and Operational Space Medicine Innovation Consortium.
2. Outline and describe key players, roles, collaborative federal opportunities in relation to DOD space medicine research.
3. Understand the clinical relevance associated with DOD space medicine research projects.

[346] THE IMPACT OF LONG-DISTANCE SPACEFLIGHT ON THE HUMAN EXPOSOME

Amelia Garner Shrader^{1,2}, Aubrey Flrom-Smith³

¹University of Alabama, Tuscaloosa, AL, United States; ²University of Alabama-Huntsville, Huntsville, AL, United States; ³Stanford University, Stanford, CA, United States

(Education - Program/Process Review)

BACKGROUND: On Earth, human health is strongly influenced by environmental exposures. The concept of long-distance space exploration is quickly becoming a reality, and astronauts will truly travel "where no man has gone before". This novel experience poses a new, unprecedented level of risk to the health of these astronauts. Space travel has well-documented risks. NASA's Human Research Program (HRP) has categorized the greatest risks to human health into five priorities: alterations in gravity, radiation, distance, hostile environments, and psychological impacts of isolation. Increased understanding of the exposome, which encompasses all environmental exposures that have the potential to affect human health, is crucial for optimizing astronaut health during long-duration missions. **DESCRIPTION:** The exposome causes changes in human DNA that is unrelated to the individual's genetics. Beyond individual priority risks, there is a high likelihood of DNA changes related to the cumulative exposomic exposures associated with space travel, including exposure to new pathogens, novel stress and psychological challenges, space radiation, and dust. Astronauts will be immersed in the whole environment of space, experiencing all of the exposure risks that entails. Therefore, a comprehensive understanding of the exposomic impact of space travel is important to inform and develop holistic mitigation strategies for associated health risks. **DISCUSSION:** The purpose of this presentation is to discuss the "big picture" of the potential effects to human health associated with exposomic exposures during prolonged space travels. It is important to consider a holistic approach when creating mitigation strategies for human health risks. The cumulative effect of multiple exposomic exposures can all have their own impact on human DNA. While small changes from one exposure may not be significant enough to lead to disease, the long-term effects and combination of the

multitude of risks may ultimately lead to devastating outcomes in exploration class astronauts. An interprofessional approach to understanding the impact of exosomic factors on astronaut health, and subsequent collaborative countermeasures and intervention design is needed to address the challenging risks of the exposome during exploration-class missions. Would like to be considered for a poster presentation if an oral presentation is not available for this topic.

Learning Objectives

1. After completion of this presentation, learners will be able to identify the exosomic risks from environmental exposures to the NASA priority risks to human health.
2. After completion of this presentation, learners will be able to describe how the exposome may be impacted by cumulative risks associated with long-distance space exploration.

Wednesday, 05/24/2023
Napoleon Ballroom A1-B3

2:00 PM

[S-64]: PANEL: TAMING VIRTUAL REALITY FOR THE NEXT GENERATION

Sponsored by the Aerospace Physiology Society

Chair: John French

PANEL OVERVIEW: *At the request of the Aerospace Physiology Society, this panel was designed to contribute to the understanding and reduction of the physiological limitations for new training techniques available through Virtual Reality (VR) technologies. There are bold steps being made to educate and train the next generation in what has been called the approaching metaverse. For example, the use of VR environments can dramatically increase understanding of medical or biological phenomenon through the ability to traverse from the macroscopic to the microscopic. VR environments can follow cells and substrates as they course throughout the organism. VR also promises to dramatically reduce the costs and dangers associated with real world training for military preparedness. These VR environments, however, also present a use-limiting factor in the form of a visually induced motion sickness (VIMS) called cybersickness. The first two presentations of this panel explore the theoretical basis for VIMS and cybersickness and provide an idea of the scope of the issues. The third and fourth panel papers focus on the incidence and severity of symptoms in new students using VR environments and ways to determine who is at risk with the aim of beginning mitigation early in training. Finally, the fifth and sixth presentations explain the Navy's use of eXtended Reality (XR) in training aviators and remotely piloted aircraft operators by the USAF with realistic countermeasure strategies. The panel extends from theory to practice with the idea of reducing cybersickness events so that the promises of a metaverse might be realized. The potential impact of VR technologies for the future of training the next generation is sufficient enough for us to request a slightly greater number of presentations allowed for a typical panel.*

[347] IS A VISUALLY INDUCED ILLUSION OF SELF-MOTION (VECTION) NECESSARY OR SUFFICIENT FOR VISUALLY INDUCED MOTION SICKNESS (VIMS)?

Ben Lawson¹, John Christopher Brill²

¹Naval Submarine Medical Research Lab, Naval Submarine Base New London, Groton, CT, United States; ²711th Human Performance Wing, U.S. Air Force Aeromedical Research Lab, Wright-Patterson AFB, OH, United States

(Original Research)

INTRODUCTION: Next-generation virtual environments (VE) will not support fully realistic training simulations until experiences beyond visual and auditory are incorporated, such as the perception one is moving through an immersive world. However, it is common to read publications asserting that visual vection (the compelling illusion of self-motion elicited by a moving visual frame of reference) is one of the

main causes of visually-induced motion sickness (VIMS). It is important to evaluate this assertion, as VIMS has challenged training among military users of visual vehicle simulators, advanced head-mounted flight displays, and unmounted VE training systems. **METHODS:** A systematic review employed Google Scholar searches and Semantic Scholar feeds to locate publications with terms such as "vection" and "sickness." Publications relevant to strong causal inference were defined as those that directly, empirically confirmed that vection could not occur without VIMS (supporting vection is necessary to VIMS), AND VIMS could not occur without vection (supporting vection is sufficient). **RESULTS:** Fifteen studies met the selection criteria, NONE of which established that vection is both necessary AND sufficient for VIMS. Five of 15 studies examined whether vection could occur without VIMS, ALL of which found this to be true. Six of 15 studies examined whether VIMS could occur without vection, four of which (67%) found this to be true. **DISCUSSION:** Vection is neither necessary nor sufficient for VIMS to occur. In fact, vection might prove beneficial for making inexpensive next-generation NATO training simulations more realistic when real field training or full motion simulator training is not feasible, e.g., via VE rehearsal of the mission during space transit of astronauts/space forces or undersea/air transit of special forces. We will discuss why a causal VIMS role for vection could be challenged on theoretical grounds, posit other causes of VIMS, and introduce preliminary findings from an ongoing review addressing the less stringent question of whether the literature supports a compelling non-causal association (i.e., a strong and significant correlation) between vection and VIMS.

Learning Objectives

1. The audience will learn about the visually-induced illusion of self motion, called vection.
2. The audience will learn that vection is not strongly causal of sickness, which is good news, and should be explored for its potential benefit to the realism of future military training simulations (in cases where it is desirable to elicit the feeling one is actually moving through the virtual world).

[348] VIRTUAL AIN'T REAL – CONSEQUENCES FOR USING VR WITH A FOCUS ON CYBERSICKNESS.

Jelte Bos

Netherlands Organization for Applied Scientific Research, Soesterberg, Netherlands

(Education - Tutorial/Review)

INTRODUCTION: New technologies often follow Gartner's hype cycle. Several, however, fail, some even repeatedly. 3D films, for example, have vanished from the scene already eight times since their introduction in 1914. The last cycle coincided with the introduction of 3D TVs, which are not manufactured anymore already since 2019. What can we learn from these failures regarding VR in general? **TOPIC:** The failures can partly be explained as followings. First, 5-20% of all people cannot "see" 3D. Second, all 3D technologies are (still) affected by the unnatural condition of a required fixed accommodation of our eye lenses, while both eyes should move to keep a sharp image on the center of both retina's. Third, only one viewpoint for each eye allows a correct view of 3D images. And last but not least, self-motion as seen by the eyes and as felt by the organs of balance in our inner ears often are in conflict. Virtual therefore differs from real, which causes visual discomfort and/or cybersickness in most VR users. Although these facts are long known, they are still often ignored. This ignorance partly concerns our basic understanding of these side-effects, which also hamper truly effective solutions that act on the core of the problem. This holds in particular for those who believe that all problems can be solved by (better) technology, while the opposite can even be true. This also holds for VR and VR goggles in particular, typically causing over three times more sickness than computer monitors do. **APPLICATION:** Consumers use VR voluntarily and can just quit when getting sick, whereas in defense applications like training and design evaluations, its use is generally involuntary. Moreover, sickness affects pleasure *and* performance. Mitigating

cybersickness is therefore of particular interest to defense organizations, typically being large-scale VR users. To facilitate adequate solutions, a NATO Specialist Team (Proietti et al., 2022, NATO STO-TR-HFM-MSG-323) recently finalized a review including guidelines for the mitigation of cybersickness, also listing knowledge gaps. A current Research Task Group (HFM-MSG-346) will elaborate on the latter, aiming at a better future for VR.

Learning Objectives

1. Virtual reality is still affected by limitations causing a different perception of the images as compared to the actual reality causing side-effects like eyestrain and cybersickness.
2. Countermeasures that act on the core of the problem should be pursued, which, however, still lacks sufficient knowledge.

[349] CYBERSICKNESS RESEARCH AND OPERATIONAL EXPERIENCES IN NAVAL AVIATION

Brennan Cox¹, Alexandra Kaplan¹, Todd Seech²

¹Naval Medical Research Unit-Dayton, Wright-Patterson Air Force Base, OH, United States; ²U.S. Navy, San Diego, CA, United States

(Education - Program/Process Review)

BACKGROUND: The U.S. Navy is developing and applying new training methodologies to produce pilots faster and with stronger skill-sets, a program referred to as Naval Aviation Training Next (NATN). One of the key enablers of NATN is the use of eXtended Reality (XR) training systems. Graduates to date have demonstrated that the program works, reaching key training milestones faster and with fewer flights than their traditionally trained counterparts. However, reports from participants of NATN indicate widespread experiences with cybersickness, leading to research and operational evaluations to characterize the extent and nature of the problem and determine how best to mitigate its effects.

OVERVIEW: Naval Aviation Training Command (NATRACOM) has included the Simulator Sickness Questionnaire as part of all students' anonymous end-of-training feedback survey since 2021. These data help inform the prevalence and severity of cybersickness experiences associated with XR use. Naval Medical Research Unit-Dayton (NAMRU-D) has further established a research program to systematically evaluate cybersickness experiences and mitigation strategies. **DISCUSSION:** Discussion will summarize results and recommendations from NATRACOM, whose data inform the operational use of XR in support of naval aviation training, and from the studies coming out of NAMRU-D, which provide a more detailed investigation of cybersickness assessments and prevention techniques. With an improved understanding of the prevalence, severity, symptoms, and associated countermeasures of cybersickness among naval flight students, attendees will be better able to evaluate the overall impact of XR training on human performance and be more knowledgeable of the current and future state of aeromedical research in this area.

Learning Objectives

1. Participants will learn about the prevalence, severity, and experience of cybersickness among users of extended reality training devices.
2. Participants will learn about specific mitigation strategies to reduce or avoid the experience of cybersickness.

[350] SHOULD WE VR THE NEXT RPA? LESSONS LEARNED IN AVOIDANCE OF VISUALLY-INDUCED MOTION SICKNESS (VIMS) IN TRADITIONAL RPA OPERATIONS

Cherie Richards

U.S. Air Force, Las Vegas, NV, United States

(Education - Tutorial/Review)

INTRODUCTION: When considering which aircraft operational platforms would benefit the most from virtual reality (VR) and augmented reality (AR) integration, Unmanned Airman Systems (UAS) operations, and specifically Remotely Piloted Aircraft (RPA), continue to present an appealing choice, but may introduce increased visually

induced motion-sickness compared to current operations. **TOPIC:** VIMS is a significant human factor limiting widespread adoption of VR and AR in flight training and operations. Having both a current technological limitation with real-time tactile feedback and increased sensory and cognitive workload, real-world use of VR in flying operations has led to frequent reports of motion sickness and rapid loss of spatial orientation in flight training settings. A fully realized VR flight environment, to include corresponding somatosensory references, potentially allows for increased visual-vestibular congruence, such that the pilot could fly virtually inside the fighter cockpit with better resistance from motion sickness. In contrast to the frontiers of the VR flight training world, RPA ground control stations would seem predisposed for VIMS, allowing for a very limited sight picture either in front of the aircraft, or a radial picture directly below, neither of which is controlled by the pilot themselves. Adapting to this limitation, RPA pilots in the now-retired MQ-1 and current MQ-9 variants fly "by numbers," ignoring the traditional environmental visual picture during transit in favor of heads-up and down display readings of aircraft state and flight indicators. This method helps to dispel many of the highest-risk visual sensory pre-conditions for VIMS, but is not without its unique challenges during manual landing and strike conditions, where the environmental picture becomes the primary display. **APPLICATION:** Using a descriptive study of pilot experience into the unique visual sight picture of the RPA platform and experiences with VR during pilot training, potential VIMS issues can be identified in operational use of VR in flight. This may provide opportunities for incorporation of lessons learned from the contemporary RPA field to next generation RPA and UAS operations.

1. Understand the difference in USAF VR flight training technology and operational RPA flight control.
1. Understand the difference in USAF VR flight training technology and operational RPA flight control.

Learning Objectives

1. The participant will be able to understand the difference in USAF VR flight training technology and operational RPA flight control.
2. The participant should be able to identify inherent risk factors for visually-induced motion sickness in operational RPA flight.
3. The audience will learn about adaptive remote flight motion sickness avoidance strategies either improved upon, or worsened by, the integration of VR technologies.

[351] MOTION SICKNESS IN VISUAL DISPLAYS: PREDICTING ONE'S SUSCEPTIBILITY VIA QUESTIONNAIRE

Behrang Keshavarz¹, John Golding²

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(Education - Tutorial/Review)

INTRODUCTION: The use of visual technologies such as Virtual Reality or driving/flight simulators can cause unpleasant side-effects associated with visually induced motion sickness (VIMS), jeopardizing the success of these technologies. Although most users get accustomed to VIMS with repeated exposure, it is crucial to understand who is at increased risk of experiencing VIMS. **TOPIC:** A variety of factors determines one's susceptibility to VIMS, including technological (screen size, resolution), situational (motion type, optic flow), and individual (age, stress) factors, making it challenging to estimate whether a user will experience VIMS or not. To date, a tool that can reliably predict VIMS susceptibility does not exist. **APPLICATION:** To improve our ability to predict VIMS, we have developed the Visually Induced Motion Sickness Susceptibility Questionnaire (VIMSSQ). A long (67-item) and a short (6-item) version of the VIMSSQ have been introduced. In both cases, the VIMSSQ tries to predict the likelihood of VIMS based on past experiences; individuals report the frequency of nausea, headache, dizziness, fatigue, or eye strain when using visual displays or devices such as smartphones, simulators, or large public displays. We conducted two experimental studies with different VIMS-inducing stimulation (rotating panoramic visual scenes) in healthy populations. Both the VIMSSQ long ($R^2=.36$)

and short version ($R^2=.34$) explained a considerable amount of variance in VIMS as measured by the Simulator Sickness Questionnaire that increased to 59% (VIMSSQ-long) and 56% (VIMSSQ-short) when other variables (susceptibility to traditional motion sickness, migraine, syncope) were added to the respective statistical models. In two large online surveys, we also collected first data from large samples that provide first insights into the general distribution of VIMS susceptibility. Overall, our results suggest that the VIMSSQ can be a useful tool for estimating one's susceptibility to VIMS, especially when used in combination with other metrics. **RESOURCES:** Golding, J.F., Rafiq, A., & Keshavarz, B. (2021). Predicting Individual Susceptibility to Visually Induced Motion Sickness by Questionnaire. *Frontiers in Virtual Reality*, 2, 3. <https://doi.org/10.3389/frvir.2021.576871>

Learning Objectives

1. The participants will learn about factors contributing to individual susceptibility to visually induced motion sickness.
2. The participants will be introduced to a novel tool predicting individual susceptibility to visually induced motion sickness.

Wednesday, 05/24/2023
Nottoway & Oak Alley

2:00 PM

[S-65]: POSTERS: HUMAN PERFORMANCE POSTERS 1

[352] DOES FREQUENT HIGH-GZ FAST JET FLYING AFFECT THE MECHANICAL PROPERTIES OF THE NECK MUSCLES? EUROFIGHTER PILOTS VERSUS MATCHED NON-PILOTS

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(Original Research)

INTRODUCTION: Fast jet pilots (e.g. Eurofighter) are exposed to accelerations of up to 9 Gz during high-performance flight maneuvers. The pilots' need to observe the airspace, requires preparation of the musculoskeletal system of the cervical spine for those loadings. Although the cervical spine has been identified as vulnerable, there is little research on the mechanical characteristics of the involved muscles. Therefore, the aim of the study was to compare pilots to non-pilots in terms of mechanical properties of the muscles involved in pilots' head movements (e.g. check-six). **METHODS:** Twenty male Eurofighter-Pilots (in possession of a valid and current flight medical) and twenty anthropometric matched non-pilots took part in the approved study (Ethics 33/2019). Exclusion criteria for pilots and non-pilots were the presence of musculoskeletal impairments in the neck region and a neck disability index score higher than 20%. To estimate the mechanical characteristics (stiffness, elasticity, frequency, relaxation, creep) of the left and right Mm. splenius capitis, upper trapezius, and sternocleidomastoids, the MyotonPRO device (Myoton, Estonia) has been used according to Myotons' current guidelines. Three repetitions of five mechanical impulses each were applied by the MyotonPRO device to defined anatomical landmarks of the laying subject. Normality distribution was assessed using Shapiro-Wilk (R, Ver. 4.2). The level of significance was set to $\alpha=0.05$ and the thresholds for Cohen's d were defined as small (0.2), medium (0.5), and large (0.8) effects between groups. **RESULTS:** Pilots showed significantly higher elasticity of the left splenius capitis ($p<.025, d=medium$), the upper trapezius

left ($p<.007, d=large$) and the upper trapezius right ($p<.008, d=large$). For the relaxation pilots also showed a faster recovery of their muscle shape from deformation after applying an external force ($p<.037, d=medium$). For the creep of the muscle, left ($p<.029, d=medium$) and right ($p<.005, d=large$) sternocleidomastoids showed higher values for the pilots. **DISCUSSION:** Due to numerous head movements during each high-Gz flight multiple times a week, differences in muscle mechanical properties were expected for pilots compared to non-pilots. It can be confirmed that the sensitivity of the method was sufficient to detect the expected changes in the mechanical properties of the muscles and therefore enables the use of such a method to long-term monitor pilot muscular (health) status.

Learning Objectives

1. Understand that high frequent, high-Gz exposure over years (fast jet pilots) lead to changed muscle mechanical properties in the head and neck region in comparison to non-pilots.
2. Understand that monitoring mechanical properties of the head and neck muscles of fast jet pilots is beneficial for their long-term health status.

[353] G-INDUCED LOSS OF CONSCIOUSNESS (G-LOC) PREDICTION USING SUPPORT VECTOR MACHINE

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(Original Research)

INTRODUCTION: High +Gz (head-to-foot direction) acceleration force induces cerebral blood loss and results in Gravity-induced loss of consciousness (G-LOC). G-LOC is a major threat to fighter pilots and may result in fatal accidents. The brain has an ability that allows transient ischemia to be tolerated without loss of consciousness during high +Gz exposure. This has been described as the functional buffer period. The functional buffer period has a duration of approximately 4-6 seconds for any +Gz exposure. Support vector machine (SVM) is one of the most popular classification methods in the machine learning. We tried to establish ten classifiers at 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5 and 5.0 sec (Classifier 0.5-5.0) to predict G-LOC within the functional buffer period by liner SVM and nonlinear SVM with Gaussian and polynomial kernels using age, height, weight, with / without anti-G suit, +Gz values, cerebral oxyhemoglobin (oxyHb) concentration and cerebral deoxyhemoglobin (deoxyHb) concentration. **METHODS:** Subjects were 124 flight course students trained with centrifuge device between 2008 and 2012. The subjects were classified into G-LOC and Non-G-LOC group. Each group had the same number of subjects. We measured trainee's cerebral oxyHb and deoxyHb concentration using near infrared spectroscopy (NIRS). The cerebral oxyHb and deoxyHb concentration were measured before +Gz load as the baseline, and during five seconds from the onset of high +Gz. The sampling rate was set at 2 Hz. **RESULTS:** Nonlinear SVM with Gaussian kernel performed better than liner SVM and nonlinear SVM with polynomial kernel. The accuracy of each classifier is as follows: Classifier 0.5, 58.1 %; 1.0, 54.8 %; 1.5, 57.3 %; 2.0, 58.1 %; 2.5, 64.5 %; 3.0, 63.7 %; 3.5, 65.3 %; 4.0, 64.5 %; 4.5, 64.5 %; 5.0, 64.5 %. **DISCUSSION:** These results demonstrate that nonlinear SVM with Gaussian kernel using age, height, weight, with / without anti-G suit, +Gz values, cerebral oxyHb concentration and cerebral deoxyHb concentration could predicted G-LOC at approximately 65% after 2.5 second. Further number of cases and factors to enhance accuracy may be needed to apply those classifiers in centrifuge training and actual flight.

Learning Objectives

1. The participant will learn about the G-LOC prediction potential using Support vector machine.
2. The participant will be able to understand that G-LOC prediction requires development of various in-flight monitoring devices.

[354] PREDICTIVE MODEL OF G TOLERANCE AND EFFECTIVENESS OF ANTI-G STRAINING MANEUVER BY USING THE PARAMETERS OF BODY COMPOSITION

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(Original Research)

INTRODUCTION: Humans can generally tolerate 4.5G to 6G induced by inertial force. In the high G flight, fighter pilots must execute the proper anti-G straining maneuver (AGSM) to increase the G tolerance. The AGSM operation will maintain brain perfusion and prevent G-induced loss of consciousness. Anaerobic fitness is always emphasized to optimize the AGSM effectiveness and G tolerance among the military pilot population. Therefore, the goal was to assess body composition and whether it could predict anti-G ability. **METHODS:** This was a cross-sectional study organized and conducted in the Aviation Physiology Research Laboratory, Taiwan. Subjects were the flight cadets recruited from the Air Force Academy and qualified by Flying Class I. Before the high G training, they were monitored by the parameters of the body composition by using a body composition machine (TANITA-BC-545N, Tokyo, Japan). Based on the loss of visual light, relaxed G tolerance, and straining G tolerance (RGT, SGT) were examined during the gradual-onset-run profile (onset rate: 0.1G/second). AGSM effectiveness was defined as the difference between the RGT and SGT. All data were managed and analyzed by the SPSS 24.0 software. **RESULTS:** There were 88 male subjects with the mean age of 25.57 in this study. Values of RGT, SGT, and AGSM effectiveness were 5.11, 7.95, and 2.84G, respectively. Body mass index (BMI) was a positive factor associated with RGT and SGT. Each unit increment of BMI would be enhanced by 37% probability at the RGT of more than 5G, and 31% probability at the SGT more than 8G. Subjects with the higher muscle mass of their left leg had better AGSM performance ($\geq 2.5G$ VS. $< 2.5G$: aOR=1.47, 95%CI: 1.03-2.11). **DISCUSSION:** These findings noted that BMI and the mass muscle of the legs were the positive factors so as to enhance the G tolerance and AGSM effectiveness. The potential explanation was mainly that the training elements of the physical condition for the high-G pilots should critically focus on the trunk and lower body muscles against the blood pooling. It would cause the significant alteration of body weight, mass, and shape. Therefore, body composition monitoring could potentially be developed as an initial screening tool to G tolerance and AGSM effectiveness.

Learning Objectives

1. To understand the effect of G force on the human body.
2. To realize the increment of G tolerance by AGSM operation
3. To observe the body composition related to G tolerance and AGSM effectiveness.

[355] LIGHT-EMITTING DIODES FOR AIRFIELD LIGHTING APPLICATIONS

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(Original Research)

INTRODUCTION: Airfield lighting (e.g., runway, approach, taxi) provide visual cues on the ground to guide a pilot to a safe takeoff, landing, or ground maneuvering operation, and are particularly useful during reduced visibility conditions. Since the 1930s, incandescent lamps have been the most common type of light source used in the United States National Airspace System (NAS). However, in response to the Energy Independence and Security Act of 2007, widespread integration of

light-emitting diode (LED) lamps in the NAS has started. This research was intended to identify human factors, operations, and safety-related considerations for using LEDs in airfield lighting. **METHOD.** Aviation transportation authority databases, Google Scholar, and conference proceedings were searched for studies evaluating the use of LEDs in airfield lighting (through August 2021). English language articles, including both published and unpublished research, were reviewed. **RESULTS.** Thirty-nine studies were identified. Ten studies on chromaticity perception found that LEDs have higher color saturation, which may provide an opportunity to better separate color boundaries and improve discriminability of airfield lights, especially in fog or haze. However, individuals with color-vision deficiencies may perform worse at color identification with certain LED colors (e.g., yellow). Eleven studies on brightness perception showed that LEDs may appear brighter than incandescent lights. Adjusting LED output could result in an undesired stroboscopic effect that may be experienced by pilots in single propeller aircraft. Additionally, LEDs may not be compatible with some flight deck vision technologies (e.g., Night Vision Imaging Systems, Enhanced Vision Systems). Eighteen studies on LED airfield hardware showed that LEDs have a longer lifespan, but may dim to unacceptably low levels over time. Additionally, LEDs may not emit enough heat to melt snow and ice in colder climates. **DISCUSSION.** The findings suggest that the use of LEDs for airfield lighting have advantages and disadvantages. FAA guidance has already addressed many of the identified concerns (e.g., LED brightness). Future research should focus on the evaluation of additional environmental factors related to weather, and include operationally relevant contexts (e.g., perception of LEDs under time pressure and within a cluttered airfield, effects of aging LEDs on color perception).

Learning Objectives

1. The audience will learn about the introduction of light-emitting diodes into airfield lighting systems in the United States National Airspace System.
2. The audience will understand the human factors, operations, and safety-related considerations for using LEDs in airfield lighting.
3. The audience will learn that LEDs are incompatible with some flight deck vision systems (e.g., Night Vision Imaging Systems, Enhanced Vision Systems).

[356] THE EFFECT OF HYPOHYDRATION ON AVIATION RELEVANT COGNITIVE PERFORMANCE

Jeffrey Phillips, Andrew Dorsey, Emily Bowers, Allison Bew, Madison McInnis

Florida Institute for Human and Machine Cognition, Pensacola, FL, United States

(Original Research)

INTRODUCTION: It has been documented that dehydration affects cognitive performance and can lead tactical aviators susceptible to common aeromedical stressors including gravitational force induced loss of consciousness (G-LOC) and spatial disorientation. Research suggests that cognitive performance is significantly affected at 2% dehydration. Conversely, an equal number of studies show dehydration does not significantly affect cognitive performance. Pilots may be especially susceptible to dehydration due to the cited practice of tactical dehydration. This study seeks to determine if passive dehydration significantly affect aspects of cognitive performance relevant to military aviation. For this evaluation, dehydration is operationally defined as a percentage deficit of body weight resulting from water loss. The current study aims to investigate cognitive performance effects across 1%, 2%, and 3% dehydration by examining participant loss of body weight. **METHOD:** Sixteen active-duty naval aviator students ($M = 25.5$ years, $SD = \pm 3.52$ years) for aviation duty participated in the study. Participants executed series of PAT and SWAY tasks across a six-hour Dehydration protocol on two separate days. Dehydration was induced by the administration of either a placebo pill or diuretic (Lasix) on one of the two testing days. To ensure fluid loss, participants were instructed not to consume any food or fluids for the duration of the six-hour protocol on each of the data collection

days. **RESULTS:** PAT and SWAY performance was analyzed through a series of repeated measures ANOVAS, which revealed no statistically significant interaction between dehydration levels and workload in either of the conditions. However, strong trends were present, suggesting that some effect on SWAY balance scores began to emerge at 3% dehydration. **CONCLUSION:** This study suggests that passive dehydration alone is not associated with significant cognitive performance impairment; moreover, heat stress and exercise related fatigue moderate the relationship between dehydration and cognitive performance. Although not significantly, the results suggest that dehydration does begin to affect balance at as low as 3%. Results must be interpreted with caution and more investigation is needed to examine the relationship between specific cognitive and perceptual performance domains and hydration across environmental exposures associated with specific military aviation mission sets.

Learning Objectives

1. The audience will learn the difference between passive and active dehydration.
2. The audience will develop a better understanding of the relationship between dehydration and psychomotor performance.
3. The audience will learn about the possible mitigation or moderation effects between dehydration and active methods to dehydrate participants.

[357] RAPID DETECTION OF HYPOXIA-RELATED IMPAIRMENT USING NON-INVASIVE NEURAL RECORDING

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²Naval Medical Research Unit-Dayton, Dayton, OH, United States

(Original Research)

INTRODUCTION: Exposure to hypoxia remains a relevant threat to aviators. Aviation safety training includes a controlled hypoxia exposure to learn symptom recognition. Prior research has shown that acute hypoxia exposure impairs sensory processing and associated neural activity. Here we advance this work closer to the training environment by assessing whether the neural markers, mismatch negativity (MMN) and P3a, are sensitive to a mask-on exposure that resembles a hypoxia training profile. **METHOD:** In this repeated-measures, single-blind design, 34 healthy adults completed two 30-min sessions that included a normoxic (21% O₂) or gradual hypoxic (14.3% - 8.1% O₂) exposure. For each session participants performed a cognitive assessment and reported hypoxia symptoms while EEG was recorded in response to auditory stimuli. After a 10-min baseline period where an on-demand hypoxia trainer (ODHT) delivered normoxic air, the gas mixture either continued to deliver normoxic or hypoxic air that increased in altitude every 5 min to 10-, 15-, 20-, and then 25-thousand-foot equivalents. Participants reported symptoms of hypoxia in real time during the session and afterwards via questionnaire. All human subjects testing was completed in accordance with NAMRU-D IRB guidelines. **RESULTS:** For the performance task, the Advanced Stoop component did reveal a time × condition interaction, whereby participants did perform progressively worse when exposed to hypoxic air. Declaration of the first noticed hypoxia symptom was evenly distributed across all altitude bins, suggesting high inter-individual variability of recognition of symptoms. MMN/P3a amplitude decreased over time in both conditions, suggesting habituation of the neural response to the auditory stimuli. However, this decrement was greater in the hypoxia condition during more extreme altitudes, suggesting a dose-dependent impact of hypoxia. **DISCUSSION:** The results suggest that an altitude profile resembling training conditions and using a relatively novel device, the ODHT, can impact neural mechanisms of sensory processing consistent with prior work. The milder effects on the MMN/P3a seen here compared with previous studies are consistent with this study's less

severe and more gradual exposure profile. Furthermore, the time course of hypoxia-induced changes in neural activity revealed here, combined with self-report and other physiological data, may help inform future aviation safety training efforts.

Learning Objectives

1. Objective 1: The audience will learn how emerging technologies in hypoxia training can be paired with physiological, behavioral, and neural recording.
2. Objective 2: The audience will learn about the time course of how the brain responds to a gradual hypoxia exposure.

[358] EVALUATING OPERATOR STATE USING EYE TRACKING AND PUPILLOMETRY IN ROTARY-WING PILOTS DURING SIMULATED FLIGHT

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(Original Research)

Flight operations in degraded visual environments (DVE) pose significant risks to the aviators completing those operations. DVE occurs when an aviator is exposed to partial or total loss of visibility due to environmental factors, such as airborne dust, sand, or snow, as well as clouds, haze, fog, and starless nights. The implementation of advanced flight controls, sensors, and cueing delivered via the visual, auditory, and tactile senses has promise to mitigate the risk of accidents and mishaps in such conditions. This is accomplished by assisting the aviator in maintaining situational awareness and reducing workload. Such technologies are already available in commercial vehicles via blind spot detectors, lane drift indicators, and back-up sensors. These use a combination of cameras and displays, audio alerts, and seat and steering wheel shakers to compensate for drivers' known limitations. These same technologies are being developed for military applications. U.S. Army Aeromedical Research Laboratory (USAARL) researchers recently completed a study evaluating the Integrated Cueing Environment (ICE) developed by U.S. Army Combat Capabilities Development Command researchers. Fourteen U.S. Army rated helicopter pilots flew 12 flight routes in a UH-60 Black Hawk flight simulator using ICE, each with a unique combination of cueing parameters, mission profiles, and injected events designed to manipulate workload. Multiple measures were collected from these pilots to give insight into their physical condition, cognitive state, and autonomic tone. As part of the operator state monitoring toolkit, a head-mounted eye tracking system was used to capture pupil diameter throughout each flight. We conducted a repeated measures analysis of variance (ANOVA) on the pupil diameter data, averaged across the duration of each flight, with the intensity of the aural and tactile cueing configurations of ICE as the within-subject factors. Tactile cueing intensity had a statistically significant effect on right eye pupil diameter at the 0.05 level ($F = 6.579$, $dfn = 1$, $dfd = 164$, $p = 0.011$). Aural cueing intensity had a statistically significant effect on left eye pupil diameter at the 0.05 level ($F = 4.670$, $dfn = 1$, $dfd = 164$, $p = 0.032$). These results suggest that more intense cueing is associated with a larger average pupil diameter, suggesting an increase in cognitive workload or heightened level of arousal.

Learning Objectives

1. How can prevent or mitigate a loss of situational awareness?
2. How does the integrated cueing environment work to support situational awareness?
3. How is pupil diameter collected in a flight simulator?

[359] CYBERSICKNESS COMPARISON IN A VIRTUAL REALITY AND TWO MIXED REALITY HEAD-MOUNTED DISPLAY CONDITIONS FOR SHORE-BASED NAVAL APPLICATIONS

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(Original Research)

INTRODUCTION: Defence Research and Development Canada is developing guidance on the use of Mixed Reality (MR) head-mounted displays (HMD) for naval operations for the Royal Canadian Navy (RCN). Virtual reality (VR) HMDs display 3-dimensional (3D) graphics to the user and completely occlude the user's view of the real world. MR HMDs overlay and integrate graphics onto the real world allowing the viewer to perceive the real world and rich 3D graphic elements simultaneously. Nausea and other debilitating symptoms caused by use of extended reality HMDs known as 'cybersickness' (CS) is well documented during VR HMD use and can be severe. However, it is not yet clear if CS is the same, more severe, or less severe when using MR HMDs. The objective of this study was to determine the impact of MR HMDs on CS. We modulated the quantity of graphics in the display and hypothesized that CS severity would increase with the quantity of graphics. **METHOD:** We compared CS scores using the simulator sickness questionnaire while participants viewed similar scenes in VR and MR in three conditions. One MR condition graphically rendered foreground objects only (called 'MR' condition) in an MR HMD. The second MR condition graphically rendered the entire scene (called 'MR+' condition) in an MR HMD. These conditions employed the Microsoft HoloLens 2 HMD. The VR condition simulated the MR+ condition in a VR HMD and employed the Oculus Rift S HMD. **RESULTS:** Findings indicated CS was significantly greater in the MR+ condition compared to the MR and VR conditions. Moreover, CS increased significantly over the 25-min session in the MR+ condition but not in the MR and VR conditions. **DISCUSSION:** We concluded that MR with low graphic quantity as in the 'MR' condition can be used over extended periods of up to 25-min with negligible CS. These findings indicate safe use of MR HMDs by the RCN for shore-based applications provided quantity of graphics is limited in the MR HMDs. In an upcoming study, the MR condition will be tested aboard an RCN vessel to determine if CS remains negligible at sea.

Learning Objectives

1. Provide an overview of the current state of cybersickness research using extended reality head-mounted displays.
2. Demonstrate that cybersickness is more severe in mixed reality head-mounted displays when the visual scene is entirely saturated with graphical elements compared to the limited cybersickness experienced with few graphical elements displayed in a mixed reality head-mounted display.

[360] THE COGNITIVE ASSESSMENT OF AVIATION PERFORMANCE STATE (CA²PES) RELIABILITY AND WORKLOAD

Emily Bowers, Jeffrey Phillips, Andrew Dorsey

Florida Institute for Human Machine Cognition, Pensacola, FL, United States

(Original Research)

INTRODUCTION: Development of a valid and reliable psychometric tool for tactical aviation has been of operational interest by the United States Air Force School of Aerospace Medicine (USAFSAM), which led to their recent development of the Cognitive Assessment of Aviation Performance State (CA²PES). CA²PES is a psychometric evaluation and an optimal tool for detecting the effects of common operational stressors on human performance. CA²PES was developed to allow researchers to examine performance effects in high and low cognitive workload settings. The inclusion of a high workload setting may detect changes not detected in common, overlearned aviation tasks. The current study is conducted in two phases. Phase 1 focused on the CA²PES test-retest reliability and

subjective workload, and Phase 2 focused demonstrating the cognitive workload effect on tracking performance. **METHODS:** In Phase 1, Ten participants ($M = 26.8$, $SD = 4.6$) were recruited from The Florida Institute for Human and Machine Cognition (IHMC) to participate in the study. All subjects completed each of the CA²PES subtasks individually, task combinations, 10 iterations of full CA²PES, and filled out the NASA-TLX after every combination of tracking and the three secondary tasks. In Phase 2, fourteen participants performed CA²PES in low and high workload mode across 4 iterations. **RESULTS:** A series of inter-class correlation coefficients (ICCs) were calculated across PCOLA Composite 1, PCOLA Composite 2, Tracking 1, and Tracking 2 as a measure of test-retest reliability. The NASA-TLX scores showed a 16.4 increase in subjective mental workload between tracking only and the full CA²PES. The repeated measures ANOVA revealed a significant effect of workload on tracking performance $f(1, 13) = 58.05$, $p = 0.000$, $partial\ eta\ square = 0.817$. **CONCLUSION:** The results of the current study suggest that CA²PES provides the ability to accurately and reliably measure psychometric tracking performance under at least two distinct levels of cognitive workload. The importance of these specific measures permits the ability for investigators to address the effects of stress at varying levels of cognitive workload to determine if there are cognitive workload by stressor interaction effects.

Learning Objectives

1. The audience will learn the importance of test-retest reliability in psychomotor research.
2. The audience will learn about the importance of testing participants under varying levels of cognitive workload.
3. The audience will learn about the potential for the use of computer adaptive psychometric tools in human performance research.

[361] IDENTIFICATION OF HYPERCAPNIA THROUGH VOICE ANALYSIS ASSOCIATED NEUROLOGICAL AND PERFORMANCE EFFECTS

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Florida Institute for Human and Machine Cognition, Pensacola, FL, United States

(Original Research)

INTRODUCTION: Due to unidentified physiologic episodes (UPEs) experienced in tactical aviation, a need exists for early detection of these occurrences in flight to ensure operator safety. Hypercapnia is believed to be a significant contributor to UPEs as operators encounter breathing resistance from oxygen mask valves, breathing hoses, and regulators, which can lead to hypoventilation and CO₂ retention. While current methods to detect hypercapnia exist, the ability to use this technology in the cockpit remains difficult due to environmental issues and interference from and with flight equipment. This investigation seeks to develop a non-invasive method to identify hypercapnia using a machine learning algorithm to detect changes in speech and breath features specific to an individual with excess arterial CO₂. **METHOD:** Thirty-five active-duty student naval aviators ($M = 24.11$ years, $SD = 2.14$) performed two iterations of the Performance Assessment Tool (PAT) and two reading tasks while breathing four normobaric CO₂ concentrations, 1.0%, 2.5%, 4.0%, 5.5%, delivered via an MBU-20/P flight mask, for 15-minutes each. **RESULTS:** Transcutaneous arterial partial pressures of CO₂ (PaCO₂) increased in participants across the four CO₂ exposures with an average increase of 15.30 mmHg from baseline PaCO₂. A repeated measures ANOVA conducted on tracking performance during PAT revealed significant differences between conditions, $f(1.69, 28.78) = 4.39$, $p = 0.027$, $partial\ eta\ square = 0.21$. Pairwise comparisons revealed significantly better tracking performance in the 2.5% and 4.0% exposure conditions when compared to the 1.0% exposure condition. Both the speech and breath machine learning approaches accurately identified the CO₂ that participants were being exposed to. The approaches based on modeling each individual's speech and breath features performed best with accuracy at 89% and 84.5% respectively. The speech and breath machine learning approaches also resulted in AUROC values in the 80s and 90s indicating that they

are excellent as diagnostic instruments to identify CO₂ concentrations.

CONCLUSION: The results of the current investigation show proof of concept that speech and breath acoustic features can be used to identify physiological stress states. Machine learning approaches should be further pursued to identify changes in physiological status and mitigate performance issues in mask worn life support breathing systems.

Learning Objectives

1. The audience will learn about the effect of carbon dioxide on human performance at high levels.
2. The Audience will learn about the potential use of machine learning to model breath whenever there is a microphone present.

[362] WIRE STRIKES AND IN-AIR OBSTACLE AVOIDANCE DURING PART 137 AGRICULTURAL OPERATIONS

Hannah Baumgartner

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(Original Research)

INTRODUCTION: Wire strikes and in-air collisions with obstacles are a leading cause of accidents in the aerial application industry. While some of these collisions occur due to previously unseen obstacles, some pilots report being previously aware of the obstacles that they collide with. Whether or not pilots are aware of obstacles pre-collision is an important factor to inform methods of accident prevention. **METHODS:** Final accident reports from the National Transportation Safety Board were retrieved for all U.S. Part 137 Agricultural Operation accidents that occurred between Jan. 2020 and Sep. 2022. Narratives, demographics, probable cause, and findings were evaluated for overall trends. A deeper analysis of cases that involved an in-air collision with an obstacle was performed, excluding cases that were attributable to an external cause (e.g., aerodynamic stall, mechanical or computer failure). For cases that involved an in-air collision with an obstacle as the primary cause of accident, the pilot's awareness of the obstacle pre-accident was inferred from narratives if available.

RESULTS: A total of 80 final accident reports were analyzed. Ten accidents included fatal injuries, 11 included serious injury, and 14 included minor injuries. Nearly half of all accidents ($n = 34$) involved an in-air collision with an obstacle (e.g., wire, tree, pole), that was not attributable to another immediate cause such as an aerodynamic stall or computer/mechanical failure. In cases where pilot awareness of the obstacle was determinable through the accident report, 44% of pilots ($n = 11$ of 25 accidents) had previously seen this obstacle yet still made contact with it. These pilots provided recommendations in accident reports that included: turning down high-risk jobs or careful route planning when close calls with in-air obstacles are unavoidable. **DISCUSSION:** Wire strikes and in-air collisions with obstacles make up a substantial portion of accidents within the Part 137 Agricultural Aviation industry. Nearly half of pilots in these cases report that they were aware of the obstacle pre-collision, indicating that inadequate preparation in scoping the field are not to blame. Instead, these findings suggest that other factors including distractions, task difficulty, and errors in decision-making may contribute to these cases. Factors that lead to wire strikes and object collisions in aerial application are important to understand to prevent future accidents.

Learning Objectives

1. Understand factors that lead to wire strikes and in-air object collisions in aerial application operations.
2. Learn recommendations regarding decision making from pilots that survive wire strikes and in-air obstacle collisions in aerial application operations.

[363] PREVALENCE OF SKIN DISCOMFORT AND PATHOLOGY IN DEPLOYED AIRCREW USING THE ATTENUATING CUSTOM COMMUNICATIONS EARPIECE SYSTEM HEARING PROTECTION SYSTEM

Phillip Strawbridge¹, Lawrence Steinkraus², Rachel Girsch¹, Paul Nelson¹

¹USAFSAM, Wright-Patterson AFB, OH, United States; ²Mayo Clinic, Rochester, MN, United States

(Original Research)

INTRODUCTION: During a deployment of a fighter unit, aircrew began to exhibit ear discomfort and episodes of auricular irritation and ulceration. All affected were using the Attenuating Custom Communications Earpiece System (ACCES). Discomfort was previously discussed in the literature, but prevalence and skin ulceration had not been previously described. **METHODS:** An anonymous paper questionnaire was used with three fighter squadrons while deployed in 2019. A total of 59 aircrew in the F-15C/E and F-16 airframes participated while aircrew not using ACCES were excluded. **RESULTS:** Response rate was 57.3% spread evenly among airframes, with 78% being pilots; 79.7% of respondents stated they had ACCES problems in the deployed setting. Among those noting problems in the deployed setting, 89% reported ear discomfort, with smaller numbers reporting skin redness, erosion, and bleeding. **DISCUSSION:** This study provided a small sample estimate of the prevalence of ear problems among fighter aircrew ACCES users while deployed. This small sample exhibited an increase in prevalence of ear discomfort during the deployment. It also showed pathological features absent in home station flying such as skin redness and erosion. The small sample and study design prevented risk factor characterization, confounder control, or causal inference. While ACCES may contribute to these problems, other confounders such as desert air characteristics, recall bias, aircrew motivation to report problems, and baseline dermatologic pathology could not be excluded. These data should serve as a baseline for larger studies better powered for confounder control and assessment of other potential risk factors. **DISCLAIMER:** The views expressed are those of the authors and do not reflect the official guidance or position of the U.S. Government, the Department of Defense, or the U.S. Air Force.

Learning Objectives

1. Anticipate aviator complaints emanating from molded communication system wear in a deployed setting with high-frequency, long-duration sorties.
2. Characterize the prevalence of discomfort and dermatologic pathology in a small sample of ACCES wearers in the deployed environment.
3. Stimulate future research into comfort and pathology of molded communication systems.

[364] COMPARISON OF THE PREVALENCE OF NECK AND BACK PAIN IN UK TYPHOON AND HAWK PILOTS

Sarah Day, Jonathan Boyd, Vivienne Lee
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(Original Research)

INTRODUCTION: Neck and back pain is known to be a potential consequence of military flying associated with exposure to high G, the use of head mounted equipment and the need to achieve unfavorable postures. The prevalence and factors associated with neck and back pain needs to be understood in order to tailor musculoskeletal injury mitigating strategies. **METHODS:** Aircrew across all UK military aircraft platforms were surveyed on MSI in 2019. The survey's core questions were based on NATO RTG Aircrew Neck Pain recommendations to determine: the prevalence of neck, upper-back and lower-back of pain in the previous 12 months; the perceived causal factors; the impact of pain in terms of flight safety. Summary statistics for Typhoon and Hawk pilots are contrasted. **RESULTS:** 172 of fast-jet and trainer aircraft pilots responded to the survey, of which 41 flew Typhoon and 32 flew Hawk. The 12-month prevalence of neck, upper-back and lower-back pain was 71 %, 39 % and 24 %, respectively, for Typhoon pilots and 33 %, 26 % and 26 %, respectively for Hawk pilots. Typhoon pilots considered high-G, night-vision goggles and helmet use with their operational tasks as the main cause of neck pain and high-G, mission type, posture with frequency of flying the main causes of upper-back pain. Hawk considered high-G, posture and equipment worn as a cause of neck pain, and seating depending on the body region. Typhoon pilots reported some impact to flight safety due to neck pain in 19 % of typical and 60 % of worst-case occurrences, compared to 0 % and 30 %, respectively, for Hawk pilots. Typhoon respondents reported a total of 295 days unfit-to-fly in a 12-month period due to neck, upper-back and lower-back pain. **DISCUSSION:** The prevalence of neck and upper-back

pain and the perceived impact to safety was greater for Typhoon pilots relative to Hawk pilots. The difference in prevalence of neck and upper back pain for Typhoon and Hawk appears to be related to the more extreme physical experience of flying high performance jets and the type of equipment used by Typhoon compared to Hawk pilots

Learning Objectives

1. The reader will understand there can be differences in neck and back pain prevalence in pilots of front-line and trainer fast-jet aircraft.
2. The reader will understand the perceived factors causing of neck and back pain in the two pilot groups and its impact on performance.

[365] A PRELIMINARY ASSESSMENT OF COGNITION AND FATIGUE DURING SIMULATED LUNAR SURFACE EXTRAVEHICULAR ACTIVITIES

Taylor Schlotman¹, Dillon Frisco², Crystal Kirkley³, Lauren Cox², Sheena Dev¹, Patrick Estep⁴, Jeffrey Somers⁵, Karina Marshall-Goebel⁵, Andrew Abercromby⁵

¹KBR-NASA JSC, Houston, TX, United States; ²JES Tech-NASA JSC, Houston, TX, United States; ³NASA Ames Research Center, Mountain View, CA, United States; ⁴GeoControl Systems-NASA JSC, Houston, TX, United States; ⁵NASA JSC, Houston, TX, United States

(Original Research)

INTRODUCTION: Exploration Extravehicular Activity (xEVA), or spacewalks, during NASA's future Lunar (Artemis) missions are expected to be more physically and cognitively demanding than any previous missions. Characterizing the effects of xEVA tasks and timelines on cognition and fatigue will be valuable, and perhaps essential to the preservation of crew health and performance during xEVA. **METHODS:** Two subjects each completed two ~5-hour simulated Lunar xEVAs in a pressurized Mark III spacesuit with one day of rest between each EVA, carrying out simulated lander operations, cable routing, crew rescue, geology, payload relocation, and traverses. Lunar gravity was simulated using NASA's Active Response Gravity Offload System (ARGOS). Subjects completed two cognitive assessments (Digit-Symbol Substitution Task (DSST) and Psychomotor Vigilance Task (PVT)) before the first and after the second simulated EVA to assess effects of xEVA tasks on processing speed (DSST) and vigilant attention (PVT). Sleep quality, duration, and efficiency was monitored (Oura Ring) for ≥ 7 days prior to the simulated EVAs, as well as between each EVA, to account for possible effects of sleep decrements on cognition metrics. **RESULTS:** Cognitive performance changed minimally from pre to post EVA for both DSST (response time (RT): S1 $\Delta 129.1$ ms, S2 $\Delta 40.7$ ms; Accuracy: S1 preEVA = 1.0, S1 postEVA = 0.98, S2 preEVA = 1.0, S2 postEVA = 1.0) and PVT (S1 PVT RT $\Delta 17.7$ ms, S2 PVT RT $\Delta -2.7$ ms). Subjects' sleep duration immediately prior to EVA showed minimal deviation from baseline (Δ hrs; S1 preEVA1 = + 0.67, S1 preEVA2 = -.03, S2 preEVA1 = - 1.1, S2 preEVA2 = -1.39) and efficiency (Δ %; S1 preEVA1 = 0.09, S1 preEVA2 = 9.54, S2 preEVA1 = 0, S2 preEVA2 = 12). Notably, sleep waketime shifted earlier for one subject by ~1 hr which may have impacted performance. **CONCLUSION:** Understanding the impacts of xEVA workloads on cognitive performance and fatigue will be instrumental to future exploration mission planning and success. Characterizing these metrics will inform modeling and prediction capabilities for planning of xEVA workload, duration, and frequency. Future work will expand the subject pool to include the full spectrum of body types, sizes, and genders represented in the astronaut population, as well as test new spacesuit designs to better simulate and evaluate performance in the xEVA suited working environment of Artemis missions.

Learning Objectives

1. The audience will learn about the impacts of simulated Lunar Exploration Extravehicular Activity (xEVA), or spacewalk, in a pressurized spacesuit on cognitive performance.
2. The audience will learn about the impacts of sleep quality, duration, and efficiency and fatigue on performance during simulated Lunar Exploration Extravehicular Activity (xEVA), or spacewalk, in a pressurized spacesuit.

[366] CAFFEINE COUNTERMEASURE AND FATIGUE MODELING OF AIRCREW IN WARGAMING SIMULATIONS

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(Original Research)

INTRODUCTION: Wargaming simulations often lack realism in regard to fatigue effects on the aircrew who are critical to mission success. In wartime, combating fatigue with sleep is difficult given operational tempo, circadian desynchrony, and stressful environments. Consequently, caffeine is commonly used as a stimulant to maintain alertness. However, caffeine's effects on subsequent sleep is not often considered. The current effort integrates caffeine effects into a wargaming fatigue modeling application to examine performance outcomes on aircrew. **METHODS:** A realistic 30-day mockup of aircrew mission schedules from the Integrated Sustainment Wargaming and Analysis Toolkit was fed into an in-house wargaming fatigue modeling application that utilizes the Sleep, Activity, Fatigue, and Task Effectiveness biomathematical model to produce fatigue estimates based on realistic sleep periods. Caffeine effects, specifically ingesting 200 mg of caffeine 1 – 3 hours before bedtime if sortie end times were within 3 hours of bedtime, were then integrated to examine primary and secondary effects on fatigue. Analyses were conducted to compare fatigue estimates without and with caffeine. **RESULTS:** Aircrew sorties without and (with) caffeine had an average of 82.94% (79.81%) and average minimum performance effectiveness of 69.54% (64.49%), with 70.45% (54.28%), 18.38% (19%), and 11.17% (26.72%) of time in the Green, Yellow, and Red bands, respectively across 110 sorties. A repeated measures ANOVA with caffeine and sortie start hour as independent measures suggested that caffeine significantly increased fatigue estimates for aircrew $F(1, 6) = 6.43, p < .05$. There was also a significant effect of sortie start hour, $F(4, 6) = 32.58, p < .001$. **DISCUSSION:** This initial integration of caffeine in a wargaming simulation showed that consistent use of a caffeine countermeasure close to sleep periods significantly increased average fatigue estimates. This suggests that the timing of caffeine ingestion needs to be taken into account if used during wartime as a fatigue countermeasure. Future work will focus on validating and extending the model with flexible caffeine addition in terms of time and amount within missions.

Learning Objectives

1. Learn about the incorporation of caffeine in a wargaming fatigue modeling application.
2. Understand the implications of consistent caffeine usage as a countermeasure close to major sleep periods on subsequent fatigue estimates and performance.

[367] ASTRONAUT SLEEP DURATION VARIES BY TIMING OF SCHEDULED SLEEP

Zachary Glaros Glaros¹, Erin Flynn-Evans¹, Rachel Jansen²

¹NASA, Moffett Field, CA, United States; ²San Jose State Research Foundation, San Jose, CA, United States

(Original Research)

INTRODUCTION: Studies find that humans average approximately six hours of sleep per night in space, which is less than they sleep on Earth. Such short sleep duration has been associated with reduced alertness and performance in space. It is unclear whether this sleep loss is related to modifiable factors, such as irregular scheduling, poor sleep environment, and excessive workload or due to features of spaceflight that alter physiology (e.g., microgravity). Recent missions have afforded crew better, more stable sleep and work schedules, and an improved sleep environment. Despite these improvements, schedules do still vary enough to cause decrements in sleep duration. **METHODS:** Crewmembers (n = 19) who volunteered for the NASA Standard Measures protocol between January 2019 and March 2022 were provided with actiwatches (Phillips, Respironics, Bend OR) that they wore for two bouts of data collection lasting two weeks each before flight (at approximately L-270 and L-180), either continuously (n = 9) or for two weeks every two months while in

space (n = 10), and for seven days postflight, immediately upon return to Earth (R+0). A regularly scheduled (or “nominal”) sleep episode would take place between the hours of 9:30pm and 6:00am. We looked at sleep outcomes (sleep duration, wake after sleep onset [WASO], sleep efficiency) depending on the distance from nominal sleep offset to see whether scheduled sleep period affected sleep durations and other metrics of sleep quality. **RESULTS:** Crewmembers provided data from 402 nights preflight, 2,137 nights in-flight, and 275 nights postflight. They averaged 7.33 hours of sleep per night (± 1.16 , SD) in space. Though this was significantly less sleep than they achieved preflight (7.87 ± 1.10) or postflight (7.75 ± 1.43 , $p < .01$), this duration of sleep meets the recommended amount for optimal human health and well-being. For every hour after the nominal sleep period a crewmember woke up (up to 5 hours), their total sleep increased by 0.33, or 20 minutes. **CONCLUSIONS:** We conclude that humans are capable of achieving sufficient sleep in space, especially when their schedules afford adequate sleep (namely, schedules that phase delay rather than advance). Future studies are needed to determine whether microgravity impacts sleep architecture and sleep quality. Going forward, it is imperative that crewmembers are provided with stable schedules, with moderate workload, and environments that are conducive to sleep.

Learning Objectives

1. The audience will learn that astronauts are achieving sufficient sleep in space, likely due to modifiable factors such as regularly timed sleep schedules, optimized sleep environment, and moderate workload.
2. The audience will learn that there are still other factors yet to be explored, such as how microgravity may impact sleep architecture and sleep quality.

[368] HOW TO CREATE IMPACTFUL IMMERSIVE SIMULATION FOR AEROSPACE MEDICINE TRAINING AND EDUCATION

Dana Herrigel¹, Michael Harrison¹, Leslie Simon¹, Nidhi Sahi¹, Colleen Donovan², Stephanie Cohen³

¹Mayo Clinic Florida, Jacksonville, FL, United States; ²Rutgers-Robert Wood Johnson, New Brunswick, NJ, United States; ³University of Central Florida, Orlando, FL, United States

(Education - Tutorial/Review)

INTRODUCTION: Immersive simulation is a valuable platform for training and education in aerospace medicine. We will describe best practices and innovative strategies to create high yield experiences optimizing individual and team performance. **TOPIC:** Hands-on, experiential learning is crucial to aerospace medicine training programs and high-performance teams. The intent of immersive learning experiences ranges widely from technical skill development/train-to-mastery, non-technical skill development (CRM/TEM), to individual and group stress response, and gauging process reliability and failure points. We will discuss best practices in creating educational objectives, optimizing critical components of simulation, and selecting debriefing strategies. Clear definition of objectives is essential to successful simulation and guides degree of fidelity and implementation strategies (i.e., live-actor versus manikin, utilization of real cases, and 4-D realism with motion, vibration, noise, and smell.) Intentional, focused pre-briefing of participants is essential. Debrief organization, such as staged debriefing or coalescing groups, and debriefing techniques such as advocacy-inquiry, plus-delta, and the After-Action Report may be employed contingent upon the objectives. Novel simulation modalities such as virtual reality, gamification, inversion, and embedded participants can be utilized to achieve unique educational goals in aerospace medicine and beyond. Finally, we will share pearls, pitfalls, and the top 5 tips for success: 1. Know the audience; 2. Understand the objectives; 3. Tailor the experience to goals; 4. Make it engaging; 5. Take it to the next level (meta-cognition). **APPLICATION:** Delivery of high-quality, impactful training is valuable to both novices and professionals in aerospace medicine. These best practices and innovative tools may be employed by aerospace medicine educators in academic settings, as well as professional civilian or military medical teams. Themes discussed are applicable to in-situ and simulation-center based experiences.

Learning Objectives

1. The participant will be able to discern meaningful Learning Objectives best achieved by immersive simulation.
2. The participant will understand innovative experiential learning techniques and their potential benefits as well as limitations.
3. The participant will be able to construct debriefing strategies optimized for the scenario.

[369] INVESTIGATING DEBRIEFING OF ADVERSE PHYSIOLOGICAL CONDITIONS TRAINING

Beth Atkinson, Mitchell Tindall, Emily Anania, Kylie Fernandez
NAWCTSD, Orlando, FL, United States

(Original Research)

INTRODUCTION: To address challenges associated with Physiological Episodes (PEs), efforts were initiated to research and develop technology solutions that will prepare aviators to respect the breathing threat through training exposures to multiple adverse physiological conditions and symptoms. While part of this research and development effort focused on expanding Mask On Breathing Device training capabilities, exploring ways to expand the instructional quality of the training was a secondary focus. **METHODS:** The instructional capabilities developed were integrated within the Aviation Reconfigurable Cockpit for Hypoxia & Hazard Exposure and Recognition (ARCH2ER) system, which offers realistic flight tasking during profile exposure and an instructor station to aid with the run time and debrief dialog associated with training. **RESULTS:** Specific instructional enhancements developed under this effort included runtime annotations and alerts, as well as data synchronization of system and instructor inputs for debriefing. During the individual profiles, instructors are provided with opportunities to track extant physiological measures and subjective measures of adverse physiological conditions and symptoms. However, exploration is underway to investigate methods for integrating eye tracking capabilities to enhance instructor tracking of performance and aviator understanding of performance degradation through enhanced diagnostic debriefing solutions. Specifically, on-going research and analysis is developing debrief systems concepts that would at a minimum include heat map displays to assist with understanding variations in scan patterns throughout the training profile. More exploratory in nature, the research team is conceptualizing hypotheses associated with fixations and erratic eye movement that might align with other symptoms (e.g., tunnel vision). **DISCUSSION:** These efforts seek to expand the training and debrief quality of dynamic breathing threat training going forward to address current training requirements. As a result, increased training efficiency offers an opportunity to increase aviator awareness of associated dynamic altitude threats, thereby increasing aviator safety and survivability.

Learning Objectives

1. Understand emerging debrief capabilities for dynamic breathing threat training associated with adverse physiological conditions.
2. Identify the ways in which eye tracking technology provide opportunities to enhance diagnostic debriefing.

[370] RESPONSES OF SALIVARY A-AMYLASE BEFORE AND AFTER THE HYPOXIA AWARENESS TRAINING

Ke-Ting Pan¹, Hung-Wei Huang¹, Wun-Wei Huang², Chao-Chien Cheng², Chung-Yu Lai¹

¹National Defense Medical Center, Taipei City, Taiwan, Greater China; ²Kaohsiung Armed Forces General Hospital Gangshan Branch, Kaohsiung City, Taiwan, Greater China

(Original Research)

INTRODUCTION: Stress is an important factor that affects work performance. During the flight, hypoxia has been recognized as a stressor to impair human performance and endanger flight safety. Salivary α -amylase has been shown to have a positive relationship with blood norepinephrine, which would increase when facing stress. Therefore, the aim of the study was to understand the change of the

salivary α -amylase before and after the hypoxia awareness training. **METHODS:** This study was a cross-sectional study conducted in October 2022 at the Aviation Physiology Research Laboratory, Taiwan. Flight cadets from the Air Force Academy were recruited to participate in the study when they attended the hypoxia awareness training. Hypobaric chamber Contract 540 (Guardite Inc., Chicago, IL) was used to undertake the hypoxia awareness training. Before and after the training, we collected the saliva from cadets and determined the value of α -amylase with a salivary α -amylase monitor (Nipro CM-21, Japan). During the hypoxia awareness training, we also recorded the time of useful consciousness (TUC) at 25,000 feet. All data were managed and analyzed by the SPSS 24.0 software. **RESULTS:** There were 22 subjects (20 males and 2 females) with an age range from 22 to 24 years old. The mean of TUC was 3.6 ± 0.9 minutes at 25,000 feet. Results showed that the value of α -amylase significantly increased after the hypoxia awareness training (Before vs. after: 14.8 ± 8.6 kIU/L vs. 21.2 ± 14.6 kIU/L, p -value = 0.036). However, the correlation between the value of α -amylase and TUC during the hypoxia awareness training was not established in this study. **DISCUSSION:** Our findings illustrated that hypoxia exposure could increase the value of α -amylase among the flight cadets. It also means that α -amylase could be a potential factor to understand the physiological responses induced by in-flight hypoxia. However, the relationship between the value of α -amylase and TUC was not determined due to the small sample size. In addition, residual confounding effects on the α -amylase such as demographic factors and lifestyle habits were not also eliminated from this study. Next work will continue to collect more data and information to clarify the change level of α -amylase by the TUC and altitude.

Learning Objectives

1. The audience will learn about the change of the salivary α -amylase before and after the hypoxia awareness training.
2. The participant will be able to understand the physiological responses induced by in-flight hypoxia.

Wednesday, 05/24/2023
Grand Ballroom A-B-C-D-E

4:00 PM

[S-66]: PANEL: 13TH ANNUAL RAM BOWL

Sponsored by the American Society of Aerospace Medicine Specialists

Chair: Allen Parmet
Co-Chair: Rebecca Blue

PANEL OVERVIEW: The 13th Annual RAM Bowl features participants from the Air Force, Navy, Army, Mayo Clinic, UTMB and international representatives competing for the Louis H. Bauer Trophy. Aerospace Medicine Residents are required to demonstrate multiple competencies to satisfy the requirements of ACGME and ABPM and serve as specialists in the field.

[371] 13TH ANNUAL RAM BOWL

Allen Parmet¹, Rebecca Blue², Joanna Nelms³, Rahul Suresh⁴, Roy Allen Hoffman⁵, Alex Garbino⁶, Walter III Dalitsch⁷, Mary Cimrmancic⁸, Joseph McKeon⁹

¹University of Southern California, Kansas City, MO, United States; ²UTMB, Galveston, TX, United States; ³Texas Air National Guard, Austin, TX, United States; ⁴NASA JSC, Galveston, TX, United States; ⁵U.S. Navy, Falls Church, VA, United States; ⁶GeoControl Systems-NASA JSC, Houston, TX, United States; ⁷U.S. Navy, Xenia, OH, United States; ⁸Marquette University, Milwaukee, WI, United States; ⁹Humana Military, San Antonio, TX, United States

(Education - Program/Process Review)

The 13th Annual RAM Bowl features participants from the Air Force, Navy, Army, Mayo Clinic, UTMB and international representatives competing for the Louis H. Bauer Trophy. Aerospace Medicine Residents are required to demonstrate multiple competencies to satisfy the requirements of ACGME and ABPM and serve as specialists in the field. Multiple tools

are available for developing appropriate didactic knowledge in aerospace medicine, public health, epidemiology, biostatistics and health care management. Residents participate in a college bowl format that test aerospace medicine competencies including the flight environment (atmosphere, radiation, vibration, acceleration, and microgravity), clinical aerospace medicine, aircraft and space vehicle systems/operations, accident investigation, historical events, aerospace physiology, human factors, ergonomics, medical standards, Federal Aviation Administration regulations, passenger transport, restraint and escape, cockpit resource management and aeromedical transportation. Questions are divided into toss-up and bonus questions. Multiple rounds of competition will lead to the selection of an individual victor and awarding of the Louis H. Bauer Trophy to the top team, sponsored by the American Society of Aerospace Medicine Specialists.

Learning Objectives

1. Participants will understand the positive predictive value of commonly used screening tests in determining public health management decisions.
2. Participants will understand gas laws and how they affect physiology during flight.
3. Participants will understand regulatory requirements for certification of civil aviation pilots in the United States.

THURSDAY, MAY 25, 2023

Thursday, 05/25/2023
Grand Ballroom

8:15 AM

57TH HARRY G. ARMSTRONG LECTURE

Student presentations from the 2023 Greater New Orleans Science and Engineering Fair

Thursday, 05/25/2023
Grand Ballroom A-B-C

10:00 AM

[S-67]: PANEL: COMMERCIAL SPACEFLIGHT APPLICATIONS FOR SPACE MEDICINE: A MULTI-CARRIER AND MISSION AGNOSTIC STANDARDIZED APPROACH

Sponsored by the Aerospace Nursing and Allied Health Professionals Society

Chair: Emmanuel Urquieta
Co-Chair: Jimmy Wu

PANEL OVERVIEW: This panel presents the results from three commercial spaceflight missions: Inspiration4, MS-20, and AX-1. The Translational Research Institute for Space Health (TRISH) has developed a commercial spaceflight research program and a standardized series of high-priority experiments to be collected across spaceflight carriers regardless of mission duration or destination. The TRISH Essential Measures encompass sensorimotor and space motion sickness, cognitive performance, physiologic monitoring, biochemical and genetic testing, and spaceflight associated neuro-ocular syndrome (SANS) surveillance. In addition, environmental data and health records are also collected. All of these datasets are coded/de-identified and stored in a database and biobank with the goal of making them accessible to future investigators and spaceflight carriers. The panel will present results from $n=9$ commercial spaceflight participants across the three missions. Each presentation will highlight the value of the data from a research and clinical perspective with a focus on its use for personalized and predictive medicine. As large standardized and diverse datasets such as the one presented here are created, the opportunity to use the data to improve mission safety, selection criteria, mission experience, and personalized medicine approaches will become a possibility.