any negative side effects of the drug administration. Again, the findings are not supportive of any further effects, and reported side effects were minimal. Further research, particularly that focuses on the role cognitive workload and intrinsic motivation may play, is required prior to recommendations regarding donepezil and its enhancement properties.

Learning Objectives

1. Participants will learn about cognitive performance and cognitive enhancement with pharmaceutical intervention.
2. Participants will learn whether, and if so, to what extent, donepezil enhances cognitive function and performance in healthy, rested Soldiers.

Wednesday, 05/08/2024 ***4:00 PM***
Grand Ballroom CD South, EF

[S-71]: PANEL: THE 14TH ANNUAL RAM BOWL

Sponsored by American Society of Aerospace Medicine Specialists

Chair: Allen Parmet
Co-Chairs: Rebecca Blue, Roy Allen Hoffman, Joanna Nelms

PANEL OVERVIEW: *The 14th 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.*

[423] THE 14TH ANNUAL RAM BOWL

Allen Parmet[1], Rebecca Blue[2], Rahul Suresh[3], Joanna Nelms[4], Roy Allen Hoffman[5], Alex Garbino[6], Walter III Dalitsch[7], Mary Cimrmancic[8], John Barson[9]
[1]*University of Southern California, Kansas City, MO, United States;* [2]*UTMB, Scottsdale, AZ, United States;* [3]*NASA/JSC, Galveston, TX, United States;* [4]*TX ANG, Austin, TX, United States;* [5]*U.S. Navy, Falls Church, VA, United States;* [6]*NASA/JSC, Clear Lake, TX, United States;* [7]*U.S. Navy, Dayton, OH, United States;* [8]*Marquette University, Milwaukee, WI, United States;* [9]*U.S. Army, Atlanta, GA, United States*

(Education - Program/Process Review)

The 14th 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. The contest will enable participants to prepare for ABPM examinations in Aerospace Medicine.
2. Attendees will receive an intense review of Aerospace and Preventive Medicine.

THURSDAY, MAY 09, 2024

Thursday, 05/09/2024 ***10:00 AM***
Grand Ballroom A

[S-72]: PANEL: PHYSIOLOGIC EPISODES IN HIGH-PERFORMANCE AVIATION: NATO WORKING GROUP FINDINGS

Chair: Ryan Mayes
Co-Chair: Erik Frijters

PANEL OVERVIEW: *Tactical aviation has a long history of physiologic episodes (PHYSEPs) associated with flight in challenging environments. However, in the last decade, pilots of multiple high-performance aircraft (fighter/attack jets and trainers) have experienced a higher-than-expected rate of these episodes in multiple services. In order to facilitate dialogue across nations regarding PEs, a North American Treaty Organization (NATO) working group was formed in 2018. With over 20 members from 10 NATO and partner nations, this group seeks to develop a better understanding of the potential causes of PHYSEPs, compare PHYSEP presentation and experience across nations and airframes, and create international consensus on causes, mitigations, and response where appropriate. This panel will present a summary the NATO working group's final report, including findings and recommendations, an overview of a proposed multinational aircrew experience study, an envisioned "end state" for how to mitigate the impact of physiologic episodes in high-performance aviation, and three presentations covering the group's "exposure matrix." The exposure matrix presentations will each describe the exposures experienced in high-performance aviation and analyze which are most critical for physiologic episodes; environmental exposures, breathing gas and equipment, and individual factors will all be discussed along with combined stressors.*

[424] PHYSIOLOGIC EPISODES IN HIGH-PERFORMANCE AVIATION: NATO WORKING GROUP FINDINGS AND NEXT STEPS

Ryan Mayes
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: in-flight physiologic episodes (PHYSEPs) among high-performance aircraft pilots have been attributed hypoxia or g-induced loss of consciousness (GLOC). Accordingly, training, pilot selection, and incident response investigations have been centered around this paradigm. However, as jet life support systems and aircrew flight equipment have improved, it stands to reason that these traditionally-attributed causes of PHYSEPs may be incomplete. In the last decade, multiple PHYSEPs have been noted among 4th- and 5th-generation fighter pilots in multiple services that do not appear to be connected to hypoxia or GLOC. **DESCRIPTION:** In order to facilitate international information sharing and create a consensus understanding of PHYSEPs, a North American Treaty Organization (NATO) working group was formed in 2018. This group has 20+ members representing 10 NATO and partner nations. The group expects to finalize its report in 2024, which will include findings and recommendations, PHYSEP classification and definition, a matrix of exposures present in the high-performance aviation environment, supporting factors such as training, sensors, and organization, and a construct for a multi-national study. **DISCUSSION:** PHYSEP symptom presentation can vary widely, and the cause of PHYSEPs are multifactorial

and variable; PHYSEPs are often a normal physiologic response to abnormal physiologic environments. An understanding of the multiple exposures that may lead to symptoms and of the potential outcomes of those exposures, is critical to understanding PHYSEPs. Not all relevant exposures and outcomes are well-understood, and the multifactorial nature of PHYSEPs requires an understanding of the interactions between exposures and physiologic responses; this requires specialized knowledge and a comprehensive and systematic assessment by a specialist. A current understanding of the rapidly evolving state of PHYSEP science is critical to assessment of PHYSEPs. A future aircrew experience study comparing PHYSEPs across multiple nations and airframes will be discussed.

Learning Objectives

1. Understand the findings and recommendations of the NATO working group.
2. Describe the differing presentations and potential causes of physiological episodes.

[425] PHYSEP END-STATE: TRAINING, ORGANISATIONAL, AND CULTURAL PROCESSES.

Adrian Smith
RAAF Institute of Aviation Medicine, Adelaide, Australia

(Education - Program/Process Review)

BACKGROUND. PHYSEPs are complex, multifactorial phenomena. Whilst it may be tempting to strive towards a system where PHYSEPs do not occur, this may not be an achievable goal in the context of high-performance aviation. **OVERVIEW.** We suggest that an achievable goal is a system where the impact of PHYSEPs is minimized. A PHYSEP-tolerant system can generate a balanced measured response to PHYSEPs should they occur, in a manner that does not unnecessarily degrade aircrew confidence or operational capability. **DISCUSSION.** Characteristics that contribute to a resilient and PHYSEP-tolerant system include training, organisational, and cultural factors. The training elements of a PHYSEP-tolerant system include an ongoing education programme that supports aircrew with information to contextualise unusual symptoms in flight, and promote a measured response by rehearsing emergency procedures and post-PHYSEP actions in a way that sustains confidence in the platform and life support systems. Training should focus on awareness of unusual symptoms or degraded performance in flight rather than focusing on specific causes. Organisational elements of a PHYSEP-tolerant system include a robust assessment process that defines a scaled classification of PHYSEPs, and investigation processes underpinned by evidence-based, data-driven, SME-informed assessments. Cultural elements of such a system include a safety culture where unusual symptoms declared in flight are not stigmatized, but are evaluated and assessed on their merit. Underlying all of these factors is clear and timely communication between commanders, aircrew, and support personnel including flight surgeons. A robust PHYSEP-tolerant system can sustain aircrew confidence and preserve operational capability by delivering a timely and proportionate response to PHYSEPs.

Learning Objectives

1. The audience will learn about the characteristics of a PHYSEP-tolerant system.
2. The audience will learn about the importance of sustaining aircrew confidence in platform and life support systems in any response to PHYSEPs.
3. The audience will learn about the importance of clear communication in any response to PHYSEPs.

[426] PHYSIOLOGIC EPISODE EXPOSURE MATRIX: METHODS, OVERVIEW AND ENVIRONMENTAL EXPOSURES

Vivienne Lee[1], Nic Green[2], Erik Frijters[3], Adrian Smith[4], Roope Sovelius[5], Michael Decker[6], Oliver Erley[7], Ryan Mayes[8]
[1]*QinetiQ, Farnborough, United Kingdom;* [2]*RAF Centre of Aviation Medicine, Henlow, United Kingdom;* [3]*Center for Man in Aviation, Soesterberg, Netherlands;* [4]*Institute of Aviation Medicine, Edinburgh, Australia;* [5]*Aeromedical Centre Finnish Defence Force, Helsinki, Finland;* [6]*Naval Medical Research Unit -Dayton, Dayton, OH, United States;* [7]*Military Aviation Authority, Cologne, Germany;* [8]*USAFSAM, Wright-Patterson AFB, OH, United States*

(Education - Program/Process Review)

BACKGROUND: It has previously been documented by a number of nations that pilots of high-performance aircraft have reported symptoms during flight, these are have become known collectively as in-flight physiologic episodes (PHYSEPs). The NATO HFM RTG-312 group has been developing a PHYSEP 'exposure matrix'. During 2023, this matrix has been progressed to provide a more detailed description of the relevance of each 'exposure' in the potential development of PHYSEPs and the knowledge gaps that exist. This presentation will provide an overview of the exposure matrix, and detail one of the four exposure matrix categories. Broadly, the exposure matrix describes cockpit environmental conditions (detailed in this presentation), life support equipment design and function, breathing gas delivery, and underlying pilot state. The matrix consists of exposures that have been assessed for the level of available evidence in the context of PHYSEPs, the likely frequency that a pilot will be exposed to each factor, the efficacy of the mitigation, the significance for PHYSEPs, and finally, the research priority as assessed by RTG-312 panel members. For each exposure, each of these parameters have been assessed as either 'high', 'medium' or 'low'. **OVERVIEW:** For environmental conditions, the key categories are low ambient pressure (altitude) and high +Gz acceleration, where the exposure frequency for both is considered to be high and the significance of both, in the context of PHYSEPs, is considered high (either in terms of likelihood, severity of symptoms or both). The level of evidence and knowledge associated with both these exposures is considered to be high. The efficacy of cockpit pressurisation and increased concentrations of oxygen in breathing gas to mitigate against low altitude is considered high in a well designed and functioning life support system. In contrast, while G protection systems are usually effective, they may not always provide adequate protection, particularly when combined with variations in underlying pilot state. DISCUSSION: Taking the rating of these factors together, it is concluded that the research priority for low ambient pressure and +Gz acceleration, in the context of PHYSEPs, are low and medium respectively.

Learning Objectives

1. Understand the the importance of factors relevant to high performance aircraft in the development of physiologic episodes.
2. Understand the research priority of environmental exposures in the context of physiologic episodes.

[427] PHYSIOLOGIC EPISODE EXPOSURE MATRIX: BREATHING GAS AND EQUIPMENT

Nicholas Green[1], Vivienne Lee[2], Erik Frijters[3], Adrian Smith[4], Roope Sovelius[5], Michael Decker[6], Oliver Erley[7], Ryan Mayes[8]
[1]*UK Royal Air Force Centre of Aviation Medicine, Henlow, United Kingdom;* [2]*QinetiQ, Farnborough, United Kingdom;* [3]*NL Center for Man in Aviation, Soesterberg, Netherlands;* [4]*RAAF Institute of Aviation Medicine, Edinburgh, Australia;* [5]*Finnish Defence Force Aeromedical Centre, Helsinki, Finland;* [6]*Naval Medical Research Unit - Dayton, Dayton, OH, United States;* [7]*Luftwaffe Center for Air and Space Medicine, Cologne, Germany;* [8]*USAFSAM, Wright-Patterson AFB, OH, United States*

(Education - Program/Process Review)

BACKGROUND: During every flight in high performance aircraft, aircrew are exposed to breathing gas characteristics that differ from the normal ambient, terrestrial environment. While some of the physiological effects are well understood, the HFM-312 Exposure Matrix identified that the impact of breathing system specification and performance has been less well explored and may have the potential to provoke unwanted physiological changes, particularly when experienced in combination with other stressors. **OVERVIEW**: The Exposure Matrix indicates

that the physiological impact of failure to deliver sufficient oxygen at increased cabin altitude is generally well known. Furthermore, this is a relatively rare event in high performance aviation due to the redundancy built into breathing systems. However, the oxygen concentration delivered can also lead to an arterial partial pressure of oxygen that is greater than sea level values, particularly when using on-board oxygen generation systems. High and fluctuating oxygen concentrations may increase the risk of acceleration atelectasis following sustained G maneuvers and have also been implicated in reducing cerebral blood flow with (as yet) unknown significance. Although the purity of breathing gas has been identified as a potential source of concern, no robust evidence of contaminated breathing gas in flight has been found. More significant is the delivery of gas flow from the breathing regulator and mask to provide an adequate response to breathing demand. Fluctuations in mask cavity pressure through the ventilatory cycle, perceived consciously or subconsciously as increased breathing resistance, could promote hyper or hypoventilation. High cognitive demand or other factors such as increased work of breathing from pilot flight equipment may increase this risk. **DISCUSSION**: Standards exist both nationally and internationally to ensure that the breathing gas supplied to high performance aviators causes minimal physiological disturbance. However, such standards must always strike a balance between performance and practicality. The final HFM-312 report will indicate that research is required into the physiological effects of mask cavity pressure change during the breathing cycle to refine existing standards. More understanding is also needed as to whether greater than sea level equivalent (or varying) arterial oxygen partial pressure has any meaningful impact on aviator performance.

Learning Objectives

1. The audience will learn about the knowledge gaps around breathing gas delivery in high performance aviation and how these might contribute to physiologic episodes.
2. The audience will learn where future research efforts on aircraft life support systems should be focussed to minimise the risk of physiologic episodes.

[428] PHYSIOLOGIC EPISODES EXPOSURE MATRIX: INDIVIDUAL FACTORS AND COMBINED STRESSORS

Erik Frijters
Royal Netherlands Air Force, Soesterberg, Netherlands

(Education - Tutorial/Review)

BACKGROUND: Aircraft life support systems are designed to sustain normal pilot physiology in military aircraft. However, pilot requirements differ greatly during normal flying conditions, aggressive manoeuvring and for egress/survivability purposes. Adding to this complexity, individual tolerances for physiological stressors can be different for each pilot. Tolerances can also vary during the day, are subject to fatigue, nutrition status, dehydration, heat stress, medical status, etc. The occurrence of a Physiologic Episode (PHYSEP) is likely an interaction between a combination of many factors. Since the introduction of high-performance military fighter jets, the occurrence of PHYSEPs has been a factor in reduced mission effectiveness and/or compromising pilot flight safety. Introduction of new aircraft, or changes to existing life support systems may cause a surge in PHYSEPs, even without system failures. The NATO HFM-312 research task group has been developing a PHYSEP 'exposure matrix'. One of the relevant elements in this matrix is the role of individual aircrew factors and combined stressors. **DESCRIPTION:** Some individuals may be more susceptible to physiological changes caused by aircraft life support systems than others. Combined stressors, such as discomfort caused by thermal burden, poor ergonomics, or inadequate mask and helmet fit can act as a margin degrader, which may increase the likelihood of the occurrence of a PHYSEP. These stressors may also interact with respiratory considerations, such as supplied oxygen concentration, inspiratory and expiratory pressures, seat posture, and pilot flight equipment. An understanding of the cumulative effect of these exposures, and how they can contribute to PHYSEPs, is critical in finding methods to mitigate and prevent PHYSEPs. **DISCUSSION:** The NATO HFM-312 panel aims to better understand the interaction between aircraft life support systems, individual factors and the effect of combined stressors on pilot physiology. By bringing together experts from 10 different NATO countries and by comprehensively examining exposures present in the tactical aviation environment, these complex interactions and PHYSEP relevance is better understood. This may help improve aircrew training, medical response, and system design to minimise undesirable physiological stimuli in the cockpit, improving flight safety and mission effectiveness.

Learning Objectives

1. Understand the interaction between aircraft systems and individual factors in the occurrence of Physiological Episodes.
2. Understand the role of combined stressors in the occurrence of Physiological Episodes.

Thursday, 05/09/2024 ***10:00 AM***
Grand Ballroom B

[S-73]: PANEL: MEDICAL EDUCATION PERSPECTIVES ON MEDICAL READINESS FOR THE OPERATIONAL ENVIRONMENT

Chair: Robert Krause

PANEL OVERVIEW: *This panel brings together professionals involved in various roles in medical education for United States Navy physicians. Panelists represent different health professions, with varied deployment experience, different command and control missions, and a civilian with specialty training in medical education and preparing units for deployment. Four of the five panelists have extensive first-hand deployment expertise. The first panelist is a previous Navy Internal Medicine Residency program director who will discuss medical education for multidisciplinary teams in the context of TeamSTEPPS to integrate learners with varied experience and clinical expertise. The second panelist will provide insight into his experience progressing from Health Professions Scholarship Program, to Flight Surgeon, to Navy Residency in Aerospace Medicine, and Senior Medical Officer of the USS John C. Stennis (CVN-74). Third, a rich discourse in pharmacogenomics and personalized medicine as they relate to modern Naval medical education will be provided. The fourth panelist is an experienced Naval provider who will provide unique insight on self-prescribed just-in-time training. Lastly, the fifth panelist will provide an overarching approach to multidisciplinary team medical education with a focus on the intersection of leadership, communication, and agility in a competency-based medical education framework.*

[429] JUST-IN-TIME-TRAINING: A LIVED EXPERIENCE

Jed Juachon
Stanford Alumni, San Deigo, CA, United States

(Education - Tutorial/Review)

INTRODUCTION: Just-in-time training (JITT) is an focused on as needed education. This can be a valuable model for the uptake of information related to novel techniques or technology. **TOPIC:** While engaged in clinical practice a new piece of technology was introduced. This device had the potential to expedite delivery and potentially improve patient outcomes. Dedicated time for education was unavailable due to clinical practice commitments. This presentation reviews a lived experience of a practitioner's self determined education prescription and how it ended up being engaged in the care of a critically ill patient. **APPLICATION:** Carving time for continuing medical education is challenging in the context of a busy clinical practice. This presentation provides a case study for attendees to use for reflection and a possible justification case to have designated JITT models related to novel or infrequently utilized techniques and technologies.

Learning Objectives
1. Define just in time training (JITT) within the medical education frame.
2. Describe a case where just in time training was an effective use of time for medical eduation.

[430] PHARMACOGENETICS AND PERSONALIZED MEDICINE.

Matthew Pena
Kaiser, Sacramento, CA, United States

WITHDRAWN

[431] THE NAVY I GREW UP IN: RENEWING OPERATIONAL READINESS COMPETENCY

Roy Hoffman
U.S. Navy, Dayton, OH, United States

(Education - Program/Process Review)

BACKGROUND: In the Navy I grew up in every new physician left their internship year anticipating that their first duty station would be in an operational unit as a general medical officer (GMO) of some variety. Deployments with those units required a rapid adaptation in your medical practice from a hospital setting with extensive services and layers of support to an unfamiliar location with minimal ancillary services and limited access to specialty care. The experience and training gained during medical school, internship, and additional operational medical training all coalesced around this common career path with known risks and limitations, but most importantly etching the responsibility of ensuring the readiness of those operational units into the core military physician competencies they would retain for the rest of their career. **OVERVIEW:** Today's post internship military physician is driven towards a vastly different career path focused on going straight to residency, time in the clinic, and preparing for leadership positions within military medicine. This results in some military physicians finding themselves in their first operational unit for the first time as a mid-grade officer with minimal operational medicine skills and a lack of prior operational experience. Gaps in delivering readiness have emerged and efforts are now underway to rudder shift to an operational focus within the Aerospace Medicine community. Policy, instructions, and training curriculum are being revised to harmoniously blend the change in physician career path with an expertise in delivering operational readiness and direct medical support. **DISCUSSION:** These ongoing efforts are extremely timely as the requirement for operational medical support has significantly increased due to a focus on the Pacific and its tyranny of distance. The future military physician will need to retain an expertise in both their medical specialty and operational readiness throughout their entire military career. The foundational framework being laid today will help to facilitate this requirement.

Learning Objectives
1. The participant will recognize the change in military physician career paths over the last couple of decades.
2. The participant will appreciate the need to keep policy and instructions up to date with changing readiness requirements.
3. The participant will understand how blending clinical and operational expertise provides for the best operational unit readiness support.

[432] INTERDISCIPLINARY MEDICAL EDUCATION

Justin P Lafreniere
U.S. Navy, Baltimore, MD, United States

(Education - Tutorial/Review)

APPLICATION: Medical education is key to providing a ready medical force within the United States Navy. Force generating multidisciplinary clinical teams poses a series of challenges. Military-specific curricula vary widely across U.S. Navy residency programs, despite guidance otherwise. Barriers include accreditation requirements with sometimes overly proscriptive and 'required' training experiences, although in recent years the ACGME has made attempts to encourage curricular innovation thru a waiver process. To our knowledge, deliberate interdisciplinary training experiences, as part of a military-specific curriculum, are minimal within U.S. Navy residency programs compared to similar civilian programs, even though graduates of military programs are likely to serve as part of a multidisciplinary team in much higher risk environments than their civilian counterparts. As a recovering U.S. Navy Internal Medicine program director recently turned Group Surgeon for Atlantic-based Fleet Surgical Teams, I've developed a dramatic perspective shift regarding military- specific curricula in residency programs and how best to train our learners to perform in the multidisciplinary operational environment. Most recent graduates approach their operational experience from a very physician-centric perspective, only to quickly encounter other members of the operational clinical team with greater breadth and depth of experience (who may also be junior in rank). Nowhere is this more evident than during team-based trauma training in which all members of Fleet Surgical Teams participate. Reactions to this experience vary, and present opportunities for multidisciplinary teachers to reinforce patient safety topics common to previous hospital-based experiences. These include: balancing leadership within a formalized hierarchy, leaning on the principles of Team STEPPS for how to create shared responsibility, cross monitoring, shared mental models, and closed-loop communication. This begs the question, if the mission of military medical education is to force generate operationally-relevant teams, should their not be more of an enterprise-wide, robust investment in teaching team-based care as part of a military-specific curriculum?

Learning Objectives
1. At the end of this presentation learners will be able to describe three challenges of providing high acuity clinical experience to service members within the US Navy.
2. At the end of this presentation learners will be able to recognize two key priorities of future medical education activities for multidisciplinary teams within the US Navy.

[433] ARCHITECTING A COMPETENCY BASED MEDICAL EDUCATION FRAMEWORK FOR MULTIDISCIPLINARY MEDICAL EDUCATION

Kathleen Samoil
Simon Fraser Univeristy, Burnaby, BC, Canada

(Education - Tutorial/Review)

INTRODUCTION: Standardized training opportunities exist for multidisciplinary teams. It may be that these opportunities can be enhanced by principles from competency based medical education (CBME) to team training. **TOPIC:** CBME is a model for the delivery, design, and evaluation learners and activities targeted to specific learning objectives. CMBE can be used across the learning continuum, from undergraduate, to post-graduate (residency & fellowship), and to continuing medical education (CME). CBME requires appropriate matching of (1) learning objectives to (2) educational intervention to (3) evaluation technique. If any are mismatched it may threaten or inaccurately reflect the attainment of learning objectives. **APPLICATION:** An example of a standardized Naval medical education course is the Fleet Surgical Team (FST) Shipboard Surgical Trauma Training (S2T2). Learners approach this multidisciplinary course with a broad range of clinical experience, and heterogeneity of rank. This robust, respected, and desired course is designed around a series of cases experienced by Naval providers. It may be that advancements in CBME architecture provide an opportunity to evolve rich medical education practices to align with this framework. A key tenet is the coordination of (1) learning objectives to (2) educational intervention to (3) evaluation technique. The underpinning of evaluation is within CMBE and readily lends itself to informing further education interventions. This assessment can be used to inform the prescription of further education interventions at both the individual and team level.

S2T2 is a highly regarded and sought after CME course with a history of preparing competent agile practitioners within high performing teams.

Learning Objectives
1. Describe the three unique elements of competency based medical education.
2. List two challenges of medical education in a team environment.

Thursday, 05/09/2024 ***10:00 AM***
Grand Hall J

[S-74]: SLIDES: AMSRO- YOUNG INVESTIGATOR

Chair: Dani Carroll
Co-Chair: Susan Northrup

[434] PIONEERING SPACE SURGEONS: MATCHING SKILLS TO MISSION NEEDS - DETERMINING THE ESSENTIAL SURGICAL EXPERTISE FOR MARS MISSIONS

Dora Babocs[1], Matthew Mark Melin[2], Siddharth Rajput[3], Gustavo S Oderich[4], Rowena Christiansen[4]
[1]*Advanced Aortic Research Program, Department of Cardiothoracic & Vascular Surgery University of Texas Health Science Center at Houston, Houston, TX, United States;* [2]*Mayo Clinic, Gonda Vascular Center, Wound Clinic, Rochester, MN, United States;* [3]*Department of Vascular Surgery, Royal Australasian College of Surgeons, Sydney, Australia;* [4]*University of Melbourne Medical School, Melbourne, Australia*

(Education - Program/Process Review)

BACKGROUND: Limited on-board spaceflight resources underscore the importance of prevention and mitigating major surgical interventions. Spaceflight medical care must consider the presentation type/severity, available resources, allocations, and resupply, and crew skill sets. While resource limitations and crew skills might indicate a 'traditional' surgical approach, minimally-invasive techniques have potential benefits despite practical challenges in the space environment. **OVERVIEW:** This study investigates surgical approaches during long-duration spaceflight through a comprehensive literature analysis. In austere (resource-limited) environments, traditional surgical techniques require less specialized equipment. However, risks include invasiveness, larger incisions, and bleeding management and fluid containment issues. Minimally-invasive techniques offer benefits such as faster healing and recovery, shorter in-patient stays, improved visualization, body compartment 'containment', and reduced infection risks. Spaceflight utilization could enhance safety, allow swift return to duties, or pre-evacuation stabilization. Terrestrial surgical approach optimization is relevant for high-risk cases, extreme environments, and austere settings. Medical care in extreme and austere environments should integrate ethical considerations, such as certain presentations in that context being deemed not survivable. **DISCUSSION:** An optimal surgical approach necessitates thorough planning, sound decision-making, a significant skill set, sound operator capacity, and utilization of available technological adjuncts. Emerging assistive technologies and minimally-invasive endoscopic methods present future promise, subject to restraints including cost, reliance on imaging (mass/volume constraints), and requiring specialized equipment and sterilization. NASA's Human Research Roadmap identifies altered sensorimotor functions, especially during critical procedural tasks, as a key spaceflight risk. Space exploration requires an integrated multi-disciplinary approach for success. In venturing beyond our planet, understanding the effects of space travel on human health, and developing appropriate medical responses becomes paramount. The synergy between traditional and cutting-edge surgical techniques could shape the future of space medicine and ensure the well-being of astronauts on their cosmic journeys. This abstract is being submitted as part of the AMSRO Young Investigators Panel.

Learning Objectives
1. The audience will gain an understanding of the comparative advantages and disadvantages of traditional surgical techniques and minimally-invasive surgical techniques.
2. Listeners will explore the advantages and challenges of employing minimally-invasive surgical techniques during spaceflight missions and their relevance for healthcare on Earth, particularly in resource-constrained and high-risk settings.
3. The audience will learn about the importance of including ethical considerations in determining whether to provide or withhold medical care in extreme and austere environments.

[435] THE INFLUENCE OF SPACE ENVIRONMENT ON CARCINOGENESIS: A COMPREHENSIVE REVIEW

Hossein Akbarialiabad[1], Nafise Niknam[2], Mohsen Farjoud Kouhanjani[2], Dedee Murrell[3], Mohammad Shafie'e[5], Seyed Ali Hosseini[2], Zahra Akbari[4], Seyedeh Maryam Mousavi[2], Armita Jokar Derisi[2], Najmeh Sadeghian[5], Marta Jurga[6], Lydia Johnson Kolaparambil Varghese[7], Rowena Christiansen[8]
[1]*UNSW Medicine, Sydney, Australia;* [2]*Shiraz University of Medical Sciences, Shiraz, Islamic Republic of Iran;* [3]*Department of Dermatology, St. George Hospital, University of NSW, Sydney, Australia;* [4]*Kerman University of Medical Sciences, Kerman, Islamic Republic of Iran;* [5]*Student Research Committee, Faculty of Medicine, Mazandaran University of Medical Sciences, Sari, Islamic Republic of Iran;* [6]*Wrocław Medical University, Wrocław, Poland;* [7]*Space Medicine Group, European Society of Aerospace Medicine, Cologne, Germany;* [8]*The University of Melbourne Medical School, Melbourne, Australia*

(Original Research)

INTRODUCTION: Space radiation and microgravity's impacts on astronaut health and cancer risk are active areas of research and are reaching critical importance as we enter the era of long-duration space exploration. While some evidence shows no increased spaceflight-induced cancer risk, others reveal potential post-mission genetic changes. Our review dives deep into this topic, consolidates current research, and sheds light on the potential oncogenic effect of spaceflights. **METHODS:** We critically analyzed 129 studies from an initial pool of 13,837. The majority were from the U.S., Germany, China, and Japan. Metrics considered include cancer types, frequency among astronauts, post-spaceflight genetic mutations, and cellular reactions to space environments. We focused on microgravity and ionizing space radiation effects. A holistic approach, considering the cumulative impact of space stressors, was adopted. All studies met ethical standards. **RESULTS:** Thyroid, breast, hematopoietic, and lung cancers were among the most studied malignancies. Among all nations, only the USA and Russia have undertaken research utilizing actual space mission conditions and human models. Intriguingly, some specific space settings seem to activate tumor suppressor genes, possibly hindering tumor growth. Microgravity affects cells both to stimulate and deter tumor development. DNA damage and impaired repair mechanisms were consistently linked with ionizing space radiation. **DISCUSSION:** The variety of findings underscores the challenge of determining space travel's oncogenic behavior. While some findings are comforting, others point to potential risks. The protective potential of some space settings and microgravity's dual effects are exciting areas for future research. However, the risks associated with space radiation cannot be ignored. Upcoming studies should adopt an integrated approach, considering the combined influence of space stressors on cancer. This knowledge is crucial for astronaut safety and understanding the long-term feasibility of space colonization. This abstract is being submitted as part of the AMSRO Young Investigators Panel.

Learning Objectives
1. To understand the impact of space environment conditions, such as microgravity and radiation, on cancer development and progression.
2. To determine the gaps in current research and highlight the need for integrative studies that examine the collective effect of space stressors on carcinogenesis.
3. Brainstorming to design a practical strategy to solve the challenges and limitations in future research.

[436] IMPACTS OF PHARMACOGENOMICS ON NASA GROUND SUPPORT AND SPACEFLIGHT PHARMACEUTICAL CARE

Thomas Diaz[1], Sincy Mathew[2], Tina Bayuse[3]
[1]*UNC Eshelman School of Pharmacy, Chapel Hill, NC, United States;* [2]*JES Tech, Houston, TX, United States;* [3]*KBR, Houston, TX, United States*

(Original Research)

INTRODUCTION: Pharmacogenomics has become the cornerstone of precision medicine, allowing healthcare providers to utilize genetic test results to guide medication selection and dosing. The use of pharmacogenomic data in astronauts may improve safety outcomes and avoid the risk of therapeutic failure in flight. The Johnson Space Center (JSC) Pharmacy is responsible for providing medications for ground support and in-flight medical kits in support of crew health and safety. This study aims to characterize the drug-gene associations that exist amongst a list of medications in order to stratify the risk of safety and efficacy outcomes of medication use for future ground and spaceflight operations. **METHODS**: The JSC Pharmacists compiled a list that includes a selection of medications that either have been or could be included in NASA ground support and spaceflight medical kits. The list of medications was cross-referenced with international pharmacogenomic sources and guidelines which provide evidence-based clinical guidance for various genetic polymorphisms: (1) Clinical Pharmacogenetics Implementation Consortium (CPIC); (2) Dutch Pharmacogenetics Working Group (DPWG); (3) Canadian Pharmacogenomics Network for Drug Safety (CPNDS); (4) French National Network of Pharmacogenetics (RNPGx); (5) United States Food and Drug Administration (FDA). Consequently, the medications in the JSC Pharmacy's list with actionable drug-gene associations was scrutinized. **RESULTS**: Of the 226 unique medications on the list, 24 (10.6%) medications have an actionable drug-gene association that may require therapeutic management based on guidance from at least one source. There are five additional medications with a drug-gene association that may affect safety, efficacy, or pharmacokinetic parameters, but their impact has yet to be fully elucidated in the literature. **DISCUSSION**: The findings of this study reveal that a considerable portion of the medications on the list analyzed possess actionable drug-gene associations. Personalized medication strategies may mitigate the risk of adverse drug reactions and optimize therapeutic efficacy to prevent medical emergencies which can compromise mission success. Ultimately, pre-emptive pharmacogenomic testing may be a valuable tool for mission planning in the context of future ground and spaceflight operations. This abstract is being submitted as part of the AMSRO Young Investigators Panel.

Learning Objectives

1. The audience will understand the significance of pharmacogenomics in NASA mission planning and its potential to optimize safe and efficacious therapeutic outcomes during spaceflight.
2. The audience will gain insight into the actionable drug-gene associations identified among medications stored in the JSC pharmacy.

[437] FUNCTIONAL AND MORPHOLOGICAL EFFECTS OF REPETITIVE OCCUPATIONAL HYPOBARIA ON THE SPINAL CORD

Sven-Erik Sönksen[1], Sven Kühn[2], André Gens[3], Frank Weber[3], Carla Ledderhos[3]
[1]*German Armed Forces Hospital Hamburg, Hamburg, Germany;* [2]*Federal Armed Forces Central Hospital Koblenz, Koblenz, Germany;* [3]*German Air Force Center of Aerospace Medicine, Cologne, Germany*

(Original Research)

INTRODUCTION: Non-hypoxic hypobaria is associated with subcortical white matter hyperintensities (WMH) on fluid-attenuated inversion recovery (FLAIR) magnetic resonance imaging (MRI) in the brain. In addition, axial injuries and decompression sickness during diving associated with hyperbaria are long-known phenomena, but little is known about the effects of isolated hypobaria on the spinal cord. **METHODS**: To assess whether the spinal cord is affected after repeated non-hypoxic hypobaria, we examined 19 altitude chamber personnel and 28 controls using spinal multiparametric MRI and posturography. The results are part of the German contribution to the NATO Research Group in Human Performance (RTG: Human Performance 274). **RESULTS**: We found neither WMH nor significant differences in total white matter, in dorsal, lateral and ventral columns, or in the two corticospinal tracts with regard to diffusivity, fractional anisotropy and magnetization transfer ratio nor any differences in posturographic parameters. Furthermore, there were no signs of atrophy or degeneration of the myelon. **CONCLUSION**: Customary hypobaric exposure in altitude chamber personnel appears unlikely to cause WMH in the spinal cord.

Learning Objectives

1. The participant will be able to understand functional and morphological effects in the spinal cord due to repetitive hypobaric non-hypoxic exposures.
2. The audience will learn about different kind of psychometric testing.

Thursday, 05/09/2024 ***10:00 AM***
Grand Hall K

[S-75]: PANEL: VIRGIN GALACTIC - YEAR 1 OF COMMERCIAL SPACEFLIGHT IN REVIEW: MEDICAL, ENGINEERING & RESEARCH OPERATIONS

Chair: Duncan Hughes

PANEL OVERVIEW: *This panel presents an overview of multiple aspects of medical engagement in suborbital spaceflight operations including the spaceflight system, flight crew, spaceflight participants (SFPs), and the many challenges inherent in supporting high-frequency operations in a fast-paced, rapidly evolving, commercial setting. The first presentation focuses on both company and medical operations including the astronaut journey, spaceflight medical support, and interdisciplinary integration with multiple teams and organizations. The second presentation addresses spaceflight participant medical screening, disease conditions, and lessons learned during the first year of commercial operations. The third presentation highlights the principles of biomedical and systems engineering (BASE) needed to integrate medical considerations into commercial operations and future vehicle design. The final presentation outlines the utility of the suborbital platform for biomedical science and highlights the medical functions required to effectively integrate research into spaceflight missions.*

[438] OVERVIEW OF COMPANY AND MEDICAL OPERATIONS FOR COMMERCIAL SUBORBITAL SPACEFLIGHT

Johnene Vardiman
Virgin Galactic, Las Cruces, NM, United States

(Education - Program/Process Review)

BACKGROUND: The medical support requirements for suborbital spaceflight differ from traditional orbital missions because of differences in spaceflight systems, mission profiles, population of potential spaceflight participants (SFPs), level of training provided, locations, and frequency of operations. Additionally, the medical role in design and testing versus high-cadence commercial operations varies significantly. **OVERVIEW:** An overview of the suborbital spaceflight system and profile is provided with a focus on the medical aspects pertinent to the different phases of flight. Highlighted are SFP medical screening and risk mitigation, medical support before, during, and after missions, contingency planning, and medical considerations for operating in a remote location. Additionally, we discuss the multidisciplinary integration of medicine to successfully support private spaceflight and research missions, lessons learned from the transition to commercial service, and future challenges of scaling medical operations. **DISCUSSION:** Providing support when transitioning from the design and testing stage of a spaceflight system to commercial operations can be a challenging process. Operational medical requirements to support a short-duration,

piloted spaceflight system with multiple layperson SFPs in austere environs requires the entire spectrum of capabilities including aviation, aerospace medicine, SFP and crew education, emergency response, and mission control. Provision of the highest standard of aerospace medical screening and support for commercial suborbital operations is a constantly evolving process that requires flexibility, multidisciplinary collaboration, and the ability to quickly pivot to fulfill design, operational, and medical needs.

Learning Objectives

1. To learn about the development of a suborbital space medicine program.
2. To learn about the changes in transitioning from conceptional to an implemented suborbital medical program.
3. To learn about the scope of projects, breadth of work with internal and external stakeholders, knowledge, and skills needed as an aerospace medicine professional working in a suborbital space medicine program.

[439] MEDICAL SCREENING AND OPERATIONAL IMPLICATIONS FOR SUBORBITAL SPACEFLIGHT PARTICIPANTS

Karen Ong, Johnene Vardiman-Ditmanson, Duncan Hughes
Virgin Galactic, Las Cruces, NM, United States

(Education - Program/Process Review)

BACKGROUND: Commercial suborbital spaceflight has unique medical considerations given the short duration of training and flight, dynamic phases of flight, and the spaceflight participant (SFP) population. Astronaut screening paradigms are discussed specific to this mission set. **OVERVIEW:** We provide an overview of the medical screening process for prospective suborbital spaceflight participants, discuss risk assessment and mitigation for a variety of medical conditions and pharmaceutical agents, and lessons learned after a year of commercial spaceflight operations. We highlight challenges in attending to the physical, mental, and emotional health of crew, mission specialists, SFPs, and family, friends, and guests. **DISCUSSION:** Medical support for missions requires not only consideration of the physiological and medical implications of the spaceflight profile but also integrating operational support and risk mitigation for medical, psychological, and emotional needs through multidisciplinary collaboration with training, engineering, maintenance, customer operations, and commercial teams.

Learning Objectives

1. The participant will learn about unique medical considerations for commercial suborbital spaceflight.
2. The participant will learn about multidisciplinary risk mitigation during commercial suborbital spaceflight.

[440] APPLICATION OF BIOMEDICAL AND SYSTEMS ENGINEERING (BASE) PRINCIPLES IN COMMERCIAL HUMAN SPACEFLIGHT

Kristen Taraszewski
Virgin Galactic, Plymouth, MN, United States

(Education - Program/Process Review)

BACKGROUND: Historically, biomedical engineers working in human spaceflight served as liaisons between the medical and engineering communities. In the evolving world of spaceflight, it is no longer adequate to simply hire an individual to implement biomedical and systems engineering (BASE) principles. Rather, the broad adoption of BASE practices by the entire space medicine community will improve safety and efficiency for the design, build, and operational stages of commercial human spaceflight. **OVERVIEW:** A brief overview of BASE principles is tailored to medical personnel working in a commercial spaceflight setting, covering fundamental concepts and terminology, processes, generation of requirements, and entrepreneurial thinking. The goal of this review is to improve efficiency with a specific focus on requirements, environmental control systems, the engineering review process, and standard business practices. **DISCUSSION:** The integration of medical requirements into commercial spaceflight engineering and operations is a complex and multidisciplinary process. In the rapidly changing environment of commercial space, BASE is an essential skillset for medical teams to understand engineering processes, effective requirement generation, and the design review cycle. Ultimately, BASE practices contribute to the agility and efficiency required to ensure the future of commercial spaceflight operations is safe, sustainable, and profitable.

Learning Objectives

1. Attendees will learn about the evolving need for the broad adoption of Biomedical and Systems Engineering (BASE) principles in commercial space.
2. The audience will gain exposure to BASE principles for medical personnel working in commercial spaceflight applications.
3. This session will discuss the use of BASE practices for the integration and execution of medical requirements in commercial spaceflight engineering and operations.

[441] MEDICAL SUPPORT FOR SUBORBITAL RESEARCH, EDUCATION, AND TRAINING OPPORTUNITIES

Sirisha Bandla
Purdue University, George Washington University, Tustin, CA, United States

(Education - Program/Process Review)

BACKGROUND: Access to research platforms in space for scientific or industrial purposes has historically been financially and logistically challenging. Parabolic flights offer limited duration microgravity exposures and orbital missions are infrequent and cost prohibitive. Suborbital spaceflight provides an intermediate platform for frequent, reliable, affordable, and repeat access to microgravity (and hypergravity) for research, training, and educational purposes. **OVERVIEW:** We provide an overview of flown biomedical sensors and platforms, previous research projects, and potential opportunities for biomedical research and mission specialist training. We discuss the role of the medical department in screening prospective researchers and payloads, integrating research projects/platforms with existing equipment and training, and post-flight support which may include medical procedures such as biological sampling or imaging. **DISCUSSION:** Given the financial and logistical challenges of orbital space experiments, the suborbital platform can serve as a testbed and training platform for future orbital experiments, many of which may involve biomedical research and potentially hazardous payloads. Immediate access to SFPs who were in microgravity just minutes prior provides a unique opportunity. Further, the increased frequency and lower cost of suborbital flights provides an attractive platform for educational payloads bolstering academic outreach and community involvement. Medical support for payload screening can help mitigate the risks to SFPs and crew, provide lessons learned for worn payloads, and improve the odds of successfully accomplishing more complex orbital space research objectives.

Learning Objectives

1. The audience will learn about the types of human-tended research being conducted onboard suborbital flights - that are now offered on a routine basis, and lessons learned for future research flights.
2. The audience will learn about various research being conducted on suborbital flights that lend to risk-reduction and further investigation on orbital flights - building a robust community for space-based research.
3. The audience will learn about our medical support and operations for commercial human spaceflights.

Thursday, 05/09/2024 ***10:00 AM***
Grand Hall GH

[S-76]: SLIDES: OCCUPATIONAL HAZARDS AND PROTECTION

Chair: Joanna Nelms
Co-Chair: Jeff Lawson

[442] SKIN PROTECTION STRATEGIES FOR AEROSPACE PROFESSIONALS WITH A FOCUS ON SUNSCREEN CHALLENGES IN THE UNITED STATES

Nikki Su[1], Tess Tarasen[2], Lesley Flynt[3], Kristine Ferrone[4], Rami Al-Rohil[5], Ashley Tarasen[6]
[1]*University of California, Los Angeles, Los Angeles, CA, United States;* [2]*Embry-Riddle Aeronautical University, Prescott, AZ, United States;* [3]*MD Anderson Cancer Center, Houston, TX, United States;* [4]*Aerospace Corporation/NASA, Houston, TX, United States;* [5]*Duke University, Durham, NC, United States;* [6]*American Institute of Dermatopathology, Los Angeles, CA, United States*

(Education - Tutorial/Review)

INTRODUCTION: Airline pilots, cabin crew, and astronauts have approximately twice the incidence of melanoma and non-melanoma skin cancer, and are more likely to die from melanoma, compared to the general population. Frequent flyers are also considered "occupationally exposed" to cosmic radiation. The demand for air travel is expected to double from 4 billion to 8 billion passengers between 2019 and 2040, underscoring the need for standardized skin protection strategies for aviation and aerospace professionals. **TOPIC:** Pilots and cabin crew are occupationally exposed to cosmic radiation, including ultraviolet A (UVA) radiation, a known carcinogen and inducer of melanoma. Solar and galactic cosmic radiation damage DNA directly, and indirectly, through the formation of reactive oxygen species, skin structural degradation, immunomodulation, and impairment of DNA repair mechanisms. Skin cancer is primarily attributed to UV radiation, genetic predispositions, and immunosuppression. Ionizing radiation attributes to an increased skin cancer incidence in atomic bomb survivors, nuclear power plant workers, and radiologists. Most UVB is blocked by the airplane window. However, in-flight UVA measurements from a pilot's seat have shown that the UVA carcinogenic effect during a 56-minute flight at an altitude of 30,000 ft. is equivalent to that of a 20-minute tanning bed session. Sunscreen use has been shown to reduce the incidence of melanoma and non melanoma skin cancer. In the United States, sun protection factor (SPF) products are regulated by the Food and Drug Administration (FDA) as over-the-counter drugs. SPF generally refers to only UVB protection, and offers no information regarding protection from UVA. Of the 14 FDA-approved filters, only zinc oxide and titanium dioxide are generally recognized as safe and effective (GRASE I); of these, only zinc oxide has an absorption spectrum to include UVA. The combination of UVA/UVB filters, antioxidants, DNA repair enzymes, nicotinamide, and retinoids may provide daily skin protection strategies for those serving in the commercial and military aviation and aerospace industries. We recommend that the Federal Aviation Administration's (FAA) preflight checklist IMSAFE be updated to IMSoSAFE to include "solar radiation". **APPLICATION:** The significantly increased incidence of melanoma and non-melanoma skin cancer in aerospace professionals underscores the need for daily skin protection methods.

Learning Objectives

1. The audience will learn about the increased incidence of, and mortality from, melanoma in pilots and cabin crew.
2. The audience will learn about the benefits of a daily skin protection routine while understanding SPF shortcomings for aerospace professionals in the United States.

[443] ALTITUDE-INDUCED DECOMPRESSION SICKNESS EVIDENCE REPORT AND PROPOSED EVALUATION PROTOCOLS

Michael Wolf[1], Wiaam Elkhatib[2], Richard Lang[2]
[1]*Mayo Clinic Rochester, Rochester, MN, United States;* [2]*Naval Medical Center San Diego, San Diego, CA, United States*

(Education - Program/Process Review)

BACKGROUND: Evolving research suggests cockpit decompression at altitude occurs more frequently and at lower altitudes than previously reported. Aerospace decompression sickness (DCS) can present subtly and lead to morbid neurological sequelae, requiring high clinical suspicion maintained by pilots, first responders, and physicians. Current literature reflects a paucity of guidance detailing decision-making response algorithm. This report intends to address this knowledge gap by reviewing published guidelines to develop treatment decision protocols for medical providers. **OVERVIEW:** Aviation DCS mechanistically overlaps with its well-studied correlate in divers with a growing literature body stimulated by prior serial fatal aviation accidents within the United States Air Force U-2 community. Following narrative literature review on the occurrence of decompression injuries resulting from altitude exposure, best clinical practices were formatted as flow charts for algorithmic and universal approaches to medical care. Inflection points in decision-making incorporate both telephone/virtual and face-to-face evaluation with progressive escalations of treatment according to tiered level of care indicated. Three flow charts were developed for procedure following rapid decompression at altitude for utilization in clinical standard operating procedures, practice guidelines, or emergency response. These encompass presence of clinical symptoms at ground-level, self-assessment screening protocol for seeking care, and pre-hospital treatment guidelines for use in a Basic Life Support response system. **DISCUSSION:** Cockpit decompression at altitude occurs relatively infrequently, though the potential for morbid resulting injury mandates high clinical suspicion when indicated. Clinical sequelae overlap with correlates in the hyperbaric environment, which should be recognized by pilots, aircrew, relevant military personnel, air traffic controllers, and those who provide medical services to them. Established management frameworks facilitate prompt recognition of and initiation of treatment for decompression injuries at altitude. The proposed schema in this report thus serve to prevent related adverse medical incidents while guiding clinical decision making.

Learning Objectives

1. The audience will understand updates about how aerospace decompression sickness (DCS) can to lead to morbid neurological sequelae, and the monitoring methods used including high clinical suspicion maintained by pilots, first responders, and physicians.
2. The audience will learn about current published guidelines in managing acute altitude decompression sickness (DCS) and their utility in developing updated treatment decision protocols for medical providers presented in this process review.

[444] EFFECTIVE TRAINING ON THE USE OF EARPLUGS - AN ISRAELI AIR FORCE EXPERIENCE

Faina Feldman[1], Sharon Gil[1], Aya Ekshtein[1], Yuval Kozlov[2], Oded Ben-Ari[1]
[1]*Aeromedical Center, Israeli Air Force, Ramat-Gan, Israel;* [2]*The Hebrew University of Jerusalem, Jerusalem, Israel*

(Original Research)

INTRODUCTION: In the Israeli Air Force (IAF) both aircrew and ground crew are exposed to harmful noise during their work. By law, the employer is obligated to instruct and train employees on the proper use of hearing protection. The most common hearing protection is earplugs made of sponge. The objectives of this study were to evaluate the effectiveness of the use of sponge earplugs among IAF members in relation

to previous instruction. **METHODS:** Data was collected from subjects who had been routinely evaluated at the Israeli Aeromedical Center between March 2020 and May 2021. Using the 3M E-A-Rfit Dual-Ear Validation System, noise reduction achieved with earplugs was measured. Participants who did not achieve at least 20dB (out of the maximum 29dB declared by the manufacturer) noise reduction were instructed on proper earplug use by the examiner and were reexamined. This study was approved by the Institutional Review Board. **RESULTS:** A total of 133 IAF members were examined with an average age of 24.6±6.7 years. There was a male and ground crew predominance (90% and 67%, respectively). Less than 50% of study participants had been previously instructed on proper earplug use, and less than 40% properly used the earplugs. Participants who had not been previously instructed achieved statistically significant lower attenuation value (16.2dB) compared to those who had been previously instructed (18.98dB, p=0.011). Participants who did not achieve the required attenuation value and were instructed on proper earplug use by the examiner significantly improved their attenuation values by an average of 8.5dB (p<0.001). **DISCUSSION:** Hearing impairment is a major health concern for military personnel. There are various hearing protection measures. Earplugs are low cost and commonly available and offer a 29dB noise reduction. However, proper use is not intuitive and straightforward as one may think, as less than 40% of our cohort was found to have used earplugs correctly. On the other hand, concise instruction on the use of earplugs greatly improved the attenuation.

Learning Objectives

1. Implementing periodic instruction on the proper use of earplugs may help reduce noise induced hearing loss.
2. Concise instruction on the use of earplugs greatly improved the attenuation values by an average of 8.5dB.

[445] IN-FLIGHT ULTRAVIOLET A (UVA) MEASUREMENTS FROM A PASSENGER SEAT

Tess Tarasen[1], Nikki Su[2], Lesley Flynt[3], Kristine Ferrone[4], Rami Al-Rohil[5], Ashley Tarasen[6]

[1]*Embry-Riddle Aeronautical University, Prescott, AZ, United States;* [2]*University of California - Los Angeles, Los Angeles, CA, United States;* [3]*MD Anderson Cancer Center, Houston, CA, United States;* [4]*The Aerospace Corporation/NASA, Houston, TX, United States;* [5]*Duke University, Durham, NC, United States;* [6]*American Institute of Dermatopathology, Los Angeles, CA, United States*

(Original Research)

INTRODUCTION: Airline pilots and cabin crew have approximately twice the incidence of melanoma, and a 46% greater likelihood of dying from melanoma, compared to the general population. Pilots and cabin crew are occupationally exposed to cosmic radiation, including ultraviolet A (UVA) radiation, a known carcinogen and inducer of melanoma. The International Commission on Radiologic Protection (ICRP) also considers frequent flyers as occupationally exposed to cosmic radiation. Airplane windows block most UVB, however, previously published in-flight UVA measurements from a pilot's seat found that a 56-minute flight at a cruising altitude of 30,000 feet had the same UVA carcinogenic effect as a 20-minute tanning bed session. To gain further insights into UVA exposure of both cabin crew and passengers, we conducted in-flight UVA measurements from a passenger seat window, and subsequently compared these data with previously published measurements from the cockpit. **METHODS:** UVA radiation measurements were performed using a SolarMeter Model 4.2 from a passenger's seat window of a Airbus 321 traveling from St. Paul, MN to Phoenix, AZ departing at 14:45 in September of 2022. The SolarMeter Model 4.2 measures UVA radiation 320-400nm. We measured UVA radiation at ground level, and an elevation of 10,000, 15,000, 20,000, 30,000, 34,000, and 36,000 feet above sea level. **RESULTS:** The amount of UVA radiation at a cruising altitude of 36,000 feet was 250 μW/cm^2. Ground level measurements during taxi varied from 27-100 μW/cm^2. Additional measurements taken during ascent were 30 μW/cm^2, 25 μW/cm^2, 20 μW/cm^2, 13 μW/cm^2, and 130 μW/cm^2 at 10,000, 15,000, 20,000, 30,000, and 34,000 ft. respectively. **DISCUSSION:** UVA is a known carcinogen and inducer of melanoma. Pilots and cabin crew have a significantly increased incidence of melanoma, and are more likely to die from melanoma, compared to the general population. We found that in-flight measurements from a passenger's seat had similar UVA exposure as previously published measurements from a captain's seat in the cockpit. Pilots and cabin crew should consider incorporating daily skin protection strategies to mitigate the risks of cumulative UVA radiation exposure in addition to other forms of cosmic radiation.

Learning Objectives

1. The audience will learn about the increased incidence of, and mortality from, melanoma in pilots and cabin crew.
2. The audience will learn that in-flight UVA exposure has the same carcinogenic effect as that of a tanning bed session.

[446] LUNG FUNCTION CHANGES AFTER ACUTE EXPOSURE TO +GZ AS ASSESSED BY IMPULSE OSCILLOMETRY

Simon Cornelissen[1], Erik Frijters[2], Gary Gray[1]

[1]*Royal Netherlands Air Force - Center for Man in Aviation, Soesterberg, Netherlands;* [2]*Royal Canadian Armed Forces - Environmental Medical Establishment, Toronto, ON, Canada*

(Original Research)

INTRODUCTION: The introduction of fifth generation fighter aircraft has raised concerns regarding the impact of high gravitational forces on lung function. This study aimed to investigate the acute effects of controlled +Gz exposure, up to +9 Gz, on lung function in military pilots using impulse oscillometry (IOS). **METHODS:** This multicenter study was conducted in two phases at facilities in Canada and the Netherlands, involving military fighter pilots undergoing high-G physiological protection training. IOS measurements were obtained using the TremofloTM IOS device, which assesses lung impedance during normal tidal breathing without forced maneuvers. 30 Royal Canadian Forces (RCAF) and 28 Royal Netherlands Air Force (RNLAF) aircrew participants were included in the study. Both performed baseline measurements. RCAF measured within 10 minutes after exposure. RNLAF within 2 minutes. **RESULTS:** Although there was a trend towards a significantly increased compliance, the RCAF study showed no significant differences in IOS parameters pre- and post-high G exposure. The RNLAF study demonstrated significantly reduced resistances and increased compliance, indicating enhanced small airway function post-high-G exposure. These findings showed no acute adverse effects of exposure to repeated +Gz on lung function. **DISCUSSION:** Both the RNLAF and the RCAF studies rule out that the combination of repeated exposure to high-Gz in combination with an anti-G suit and the performance of Anti-G Straining Maneuvers (AGSM) has acute negative effects on airway impedance parameters. The breathing component of the AGSM, likely produced increases in intrathoracic pressure, stretching the small airways and thus decreasing small airway resistance and increasing reactance. The difference between the non-significant trend in RCAF results within 10 minutes and significant changes in the RNLAF study results within 2 minutes, suggests that this effect is transient.

Learning Objectives

1. The audience will learn that acceleration atelectasis does not occur without high concentrations of oxygen in repeated exposure to medium and high +Gz, in combination with AGSM.
2. The audience will learn how the breathing component of the AGSM and high +Gz acutely changes lung function, and that this is a short term effect.

[447] ASSESSMENT OF G-ENDURANCE TOLERANCE OF INDIVIDUALS ON MODAFINIL DURING EXTENDED PERIOD OF WAKEFULNESS

Marur Nataraja

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(Original Research)

INTRODUCTION: Modafinil as an alertness enhancing drug has been authorized for use among aircrew of IAF. This study was conducted with an aim to assess the effect of Modafinil on the G endurance tolerance on sleep deprived individuals. **METHODS:** Twelve healthy male volunteers participated in the study on two different days viz. once as part of control group with placebo and second time as part of study group on single dose of Modafinil 200 mg at 2300 h. In the 'between the group' design, relaxed +Gz tolerance & +Gz endurance tolerance were assessed using High Performance Human Centrifuge (HPHC) before and after intervention with Modafinil. Physiological variables like Heart Rate (HR) and Blood Pressure (BP) were measured before, during and after exposure to +Gz in the HPHC. Subjective perception of fatigue was assessed using Chalder's fatigue questionnaire. **RESULTS.** The results were analysed using repeated measures ANOVA which indicated that Modafinil significantly increased the HR and BP among the subjects in the study group ($p<0.05$). However, these parameters were maintained steady during exposure to +Gz stress. Subjective perceptions of sleepiness and fatigue were significantly attenuated with Modafinil ($p<0.05$). The G Endurance tolerance of participants on Modafinil was significantly increased as compared to those in the control group ($p<0.05$). **DISCUSSION:** The findings of our study suggested the possible sympathomimetic action of Modafinil resulting in significant sustained elevation in both blood pressure and heart rate. The intervention with Modafinil showed significant effects on G endurance tolerance due to a strong ergogenic effect of the drug. The subjective perception of work effort of doing Anti-g Straining Maneouvre (AGSM) was less among participants in study group as compared to control group.

Key Words: G tolerance, Modafinil, SACM, Fatigue, HPHC

Learning Objectives

1. The participant will be able to understand that Modafinil is helpful in maintaining alertness during extended duration of wakefulness. The subjective perception of sleepiness and fatigue would be significantly attenuated with administration of Modafinil.
2. The participant will be able to understand that intervention with Modafinil does not interfere with the relaxed G-tolerance of an individual. However, it significantly increases the G-endurance tolerance due to modest sympatho-mimetic effects and a strong ergogenic effect of Modafinil enabling better combat capability.

Thursday, 05/09/2024 ***10:00 AM***
Grand Ballroom AB

[S-77]: PANEL: UTMB – 30 YEARS OF EXCELLENCE: HOW WE BUILD THE FUTURE OF AEROSPACE MEDICINE.

Chair: Ronak Shah
Co-Chair: Serena Auñón-Chancellor

PANEL OVERVIEW: *"We believe in the success of every human who endeavors to travel to the skies." This is the vision statement of the Aerospace Medicine team at the University of Texas Medical Branch (UTMB). The purpose of this panel is to share major educational updates seen in the past 1 ½ years, provide a look at both current and future operations, and explain the internal and external variables that impact both the short-term tactical and long-term strategic thinking of the team. The first presentation will be an overview of the new Master of Science in Aerospace Medicine. It will explore the thought process behind transitioning from the historical Master of Public Health degree, what curriculum components were changed and what new, innovative approaches are now being implemented. The second presentation will provide insight into ongoing consortium efforts and international training pathways. As the field of Aerospace Medicine evolves, it does so on both a domestic and global scale. The presenter will share aspirations of the consortium, current efforts at UTMB for international support, and ideas for future growth. This will be followed by an in-depth look at the newly formed 4-year combined Emergency Medicine/Aerospace Medicine residency as UTMB seeks to expand training opportunities. The speaker will elucidate the rationale behind the idea itself, what resources were needed to execute a plan, and how this endeavor was truly a collaborative effort between different institutional departments and different boards. From here the panel will segway into research efforts. More specifically, the presenter will discuss the driver behind an enhanced focus on research education and training as well as specific projects that both past and present UTMB residents have undertaken. The panel will conclude with a perspective from the UTMB Aerospace Medicine Chief Resident. The goal is to share not just the faculty point of view, but to balance that with the perception of the individual who is recipient of the very education that UTMB Aerospace Medicine provides. Overall, the goal is to demonstrate how mindful actions at UTMB have brought this program – now in its 30th year - one step closer towards its vision.*

[448] MASTER OF AEROSPACE MEDICINE, ADAPTING CURRICULUM TO LEARNER NEEDS

Amy Kreykes, Serena Auñón-Chancellor, Ronak Shah
UTMB, Galveston, TX, United States

(Education - Program/Process Review)

BACKGROUND: Aerospace Medicine board eligibility via the American Board of Preventive Medicine requires completion of a Master of Public Health (MPH), or equivalent, degree. The University of Texas Medical Branch (UTMB) Aerospace Medicine Residency has traditionally provided residents with an education resulting in a MPH degree. Recent nationwide changes to the MPH competencies made by the Council on Education for Public Health (CEPH), feedback from recent graduates, and input from potential employers of Flight Surgeons prompted the University of Texas Medical Branch to re-examine the curriculum and adapt it to better suit the needs of our residents. **OVERVIEW:** A new curriculum comprising a Master of Science in Aerospace Medicine was tailored to UTMB residents based on feedback from identified stakeholders. It includes approximately 100 hours of Aerospace Medicine specific content in addition to the core courses required for board eligibility. Examples of topics covered include complex aeromedical certification, fundamentals of aerospace physiology, women's health in spaceflight, medical operations to include launch and landing efforts, acute care response, risk management, and introductory principles to mishap investigation and response. In addition, UTMB has partnered with a commercial space company that will be providing a customized overview of systems engineering and approach to the development of requirements for non-engineers. We are proud to partner with experts in the field to provide this new curriculum to our residents. **DISCUSSION:** As mission architectures for space and aviation evolve, so too must the education for physicians in pursuit of Aerospace Medicine. Through the lens of a multi-disciplinary core faculty, and the input of both government and industry stakeholders, the UTMB residency is proactively innovating and preparing for the future.

Learning Objectives

1. The participant will be able to identify differences in the former MPH curriculum and the current MS curriculum at UTMB.
2. The participant will have a better understanding of the type of content included in the MS curriculum.

[449] BUILDING PARTNERSHIPS AND INTERNATIONAL TRAINING PATHWAYS

Serena Auñón-Chancellor
UTMB, Galveston, TX, United States

(Education - Program/Process Review)

BACKGROUND: Both domestic and international institutions are seeking opportunities to gain access to education in Aerospace Medicine. **OVERVIEW:** The number of people flying to space and the need for

qualified Aerospace Medicine specialists to serve as their flight surgeon has skyrocketed in recent years. UTMB has continually evolved its curriculum and access to education over the years to help meet the needs of both government and industry. More recently, UTMB has had a large number of requests from several academic institutions both domestic and abroad regarding pathways to develop their own expertise in the field. **DISCUSSION:** UTMB has answered this increased interest by the creation of a formal Aerospace Medicine consortium involving many other large academic institutions. By bringing together our strengths in research, engineering, and the clinical realm, this ensures that both the number and quality of our graduates continues to be optimized. In addition to this, many international countries have sought increased access to formal Aerospace Medicine training as opportunities locally may be limited. UTMB has engaged with many of these entities to provide our support and guidance with these endeavours. Proposals have included development of small educational curriculums and even the creation of a formal training program that aspires to parallel the guidelines of board certified Aerospace Medicine specialists.

Learning Objectives

1. The participant will be able to describe the merits of increased collaboration in the Aerospace Medicine education arena.
2. Participants will be able to describe different pathway opportunities for international training.

[450] A NOVEL 4-YEAR COMBINED EMERGENCY MEDICINE/ AEROSPACE MEDICINE RESIDENCY AT UTMB

Natacha Chough, Ronak Shah, Serena Auñón-Chancellor, Amy Kreykes, Rebecca Blue
UTMB, Galveston, TX, United States

(Education - Program/Process Review)

BACKGROUND: The success of Aerospace Medicine as a specialty is premised on the multi-disciplinary backgrounds of its providers. Over the past 30 years, UTMB has offered categorical and combined ACGME-accredited residency options to produce board-eligible and board-certified Aerospace Medicine physicians for the industry's workforce. Advances in aerospace, including an increase in commercial spaceflight, drive the need for additional training programs to expand the existing pipeline of appropriately trained physicians eligible for hire throughout this growing sector, while still maintaining established medical education standards. **OVERVIEW:** With the advent of UTMB's new Emergency Medicine residency, and the concurrent growth in the aerospace industry driving a need for a greater number of qualified practitioners, the UTMB Aerospace Medicine Division believed it a natural fit to pair these medical specialties together. The development process included initial internal institutional dialogue, a metrics review of past trainees' primary specialty backgrounds, detailed discussions with ABEM & ABPM, hire of appropriate faculty to expand Division support capabilities, and curriculum construction, prior to the release of the final product. Additional educational support from EM/AM colleagues in the commercial space sector will also be incorporated. This pathway received formal approval from both the American Boards of Preventive Medicine and Emergency Medicine, with each component being ACGME-accredited. Applications opened in 2023 for the start of July 2024. We look forward to sharing this novel approach to creating additional training pathways in Aerospace Medicine. **DISCUSSION:** Competent medical support of aerospace endeavors stems from sufficient ACGME-accredited training program opportunities for physicians seeking to specialize in this field. Increasing the number of accredited Aerospace Medicine training programs will produce more graduates qualified to perform this work and match industry growth. This is of global interest to professionals in a position to develop educational programs to address training gaps in their respective communities.

Learning Objectives

1. Learn the driving factors leading to the need for more Aerospace Medicine practitioners.
2. Understand the components involved in the creation of new Aerospace Medicine training programs.

[451] AEROSPACE RESIDENCY RESEARCH: EXPANDING DATA-DRIVEN LITERATURE AND DEVELOPING SCIENTIFIC ACUMEN

Rebecca Blue, Amy Kreykes, Natacha Chough, Serena Auñón-Chancellor, Ronak Shah
UTMB, Galveston, TX, United States

(Education - Program/Process Review)

BACKGROUND: In aerospace medicine, the need for data-driven decision-making and the corollary of data publication and peer review must be balanced against the need for careful and effective protection of patient privacy. Historically, aerospace medical publication has been limited to small cohorts and often delayed presentation of data to allow deidentification of sources. Simultaneously, some historical medical events never reach publication as the risk of violation of privacy is considered too high; as a result, some medical knowledge can only be gained through experience or direct clinical practice. Thus, our community has struggled to aggregate sufficient evidence to support data-driven decision-making on even common spaceflight medical events and has further struggled to communicate rationale behind common practices. With the expansion of the commercial spaceflight industry, the ability to pursue rapid aggregation and presentation of medical findings is critical for the evolution of aerospace clinical practice to keep pace with current and future operations. Simultaneously, new physicians entering aerospace practice must be capable of reviewing data from even limited sources to determine impacts to clinical practice and validity of evidence sources. **OVERVIEW:** UTMB is actively pursuing expansion of aerospace resident education and engagement in clinical spaceflight research activities, with objectives including developing robust resident skills in validating and synthesizing data and determining applicability to their own clinical practice. Further, training in research skills allows new graduates to contribute meaningfully to future scientific literature, further evolving data-driven clinical practice. This presentation will review the development of a training architecture to educate residents and develop research skillsets. **DISCUSSION:** As the commercial industry has led to rapid development of expansive and variable operational environments for human spaceflight, physicians entering aerospace medical practice must similarly expand their skillsets in understanding, aggregating, and applying clinical experience to their own medical practice. In providing an educational framework to understand and engage in clinical research, we can offer a foundational pathway for future clinical practice evolution and evidence-based medical practice as well as for the ethical presentation of future medical findings for the benefit of all.

Learning Objectives

1. Attendees will learn about UTMB's approach to residency research education and engagement.
2. Attendees will hear about prior and ongoing resident research efforts in Aerospace Medicine.

[452] PUTTING IT ALL TOGETHER: PERSPECTIVE FROM THE CHIEF RESIDENT

Rebecca Mendelsohn
UTMB, Galveston, TX, United States

(Education - Program/Process Review)

BACKGROUND: Upon graduation, many Aerospace Medicine residents are embarking on entirely new career paths compared to their predecessors just a decade ago. To ensure that trainees continue to receive cutting-edge education in this rapidly evolving field, the University of Texas Medical Branch (UTMB) has updated its curriculum to incorporate innovative and invaluable academic and rotational experiences into its Aerospace Medicine residency program. **OVERVIEW:** This fall, UTMB introduced a Master of Science in Aerospace Medicine into its first-year curriculum. This program provides a multi-faceted foundation of knowledge in Aerospace Medicine and, of note, introduces an approach to systems engineering thru the lens of a commercial space provider. To combine this academic knowledge with real-world experience, the

program includes longitudinal rotations at NASA's Johnson Space Center. In the second year, trainees are afforded the opportunity to create unique experiences that will benefit their specific career choices. This year, residents have cared for altitude-related maladies in the Himalayas, collaborated on projects with the UK's Civil Aviation Authority in London, joined USAF colleagues in CBRN training exercises, and drafted emergency medical protocols for new commercial space companies. **DISCUSSION:** With the advent of the commercial space industry, the field of aerospace medicine is rapidly expanding, requiring training programs to adapt to new educational and training needs. UTMB's program advances the field of aerospace medicine by ensuring that trainees are receiving the experiences and education that they need in these new roles.

Learning Objectives

1. During this presentation, the audience will learn about cutting-edge approaches to aerospace medical education.
2. After this presentation, the audience will be familiar with the impact of real-world rotational experiences on creating unique educational pathways for Aerospace Medicine Residents.

Thursday, 05/09/2024 ***10:00 AM***
Grand Suites 2 & 3

[S-78]: POSTERS: OUT OF THIS WORLD POSTERS

Chair: Yael Barr
Co-Chairs: Jamie Harvey, David Alexander, Andrea Hanson

[453] DEATH IN SPACE: END OF LIFE CARE AND MISSION PLANNING

Imelda Muller, Jace Bradshaw
Johns Hopkins, Baltimore, MD, United States

(Education - Program/Process Review)

BACKGROUND: Several models have been developed to build architecture around the most likely medical conditions that will be encountered during space missions (eg. Integrated Medical Model (IMM), Long Duration Lunar Orbit and Lunar Surface (LDLOLS) Models). With longer duration space missions, the list of possible medical conditions that will be encountered continues to grow. Palliative care and expectant management must be woven into the gold standard of space medicine. **OVERVIEW:** The IMM was used to identify 100 likely medical conditions that could be encountered over a particular range of mission capabilities. With NASA's plans for long duration space flight and expansion into the solar system, implications of additional pathologies must be considered, such as chronic disease states. Given the material constraints inherent in interplanetary flight, it is prudent to consider higher morbidity and mortality rates similar to those encountered in austere terrestrial environments. While several individuals have died in space, no such event has involved crew-based care for a dying individual while also continuing a long duration space mission. The care of a dying crew member has mission impacts beyond a reduction of manning and the operational, biological, and psychological implications must be thoroughly considered. Preparedness for space missions of any duration should include a plan for palliation and death of a crew member. This training for crew members should include identification of medications/resources that can be allocated for end of life care and integration of personal and cultural practices. Lessons from austere terrestrial environments and prolonged military field care can be applied to end of life care in space. **DISCUSSION:** What does a "good death" look like in Space? While the answer to this question is incredibly personal and diverse, principles of palliative care should be applied to the developing model of celestial medicine. Unlike the management of other medical conditions, a major advantage of expectant management and palliative care are the minimal resources and training necessary to execute this response effectively. These principles can be integrated into the ever-changing architecture of space medicine and could ultimately help minimize detrimental mission impacts of an otherwise catastrophic loss.

Learning Objectives

1. Identify gaps in knowledge related to palliative and end-of-life care on space missions.
2. Describe operational, biologic, and psychological implications of a crew member's death, particularly during long duration space travel.
3. Describe how basic principles of palliative and end-of-life care in both resource rich and poor terrestrial environments can be applied to short and long duration space missions.

[454] EVALUATING THE VALUE OF A NEW 'SPACE HEALTH' CURRICULUM THROUGH THE LENS OF STUDENT REFLECTIONS

Rowena Christiansen[1], George Pantalos[2]
[1]*The University of Melbourne, Melbourne, Australia;* [2]*University of Louisville, Louisville, KY, United States*

(Education - Program/Process Review)

BACKGROUND: In 2022, the University of Melbourne Medical School launched a new integrated 'Discovery' subject stream as a core component of the graduate medical curriculum. 'Flagship' MD1 Discovery subjects included "Human health in the space environment" (24 weeks). Each student cohort completes three assessments: a group video project, a written report, and a final reflective Space4Health 'spinoff' presentation. Active reflection spans personal insights into the value of what has been learned from the subject and researching 'spinoffs', and how this could apply to future professional practice. Analysing these reflections allows assessment of whether two course objectives of creating awareness of the translational value of space research, and an appreciation of many key qualities for success that students can carry forward into their future careers, are being achieved. **OVERVIEW**: Although the reflective element was a key assessment and marking rubric component, not all students specifically included it, or referred to their future professional practice. Out of 22 students, 17 provided at least one slide specifically describing the translational benefits of space research, its value, or applicability to their professional practice. 14 students included clearly identifiable personal reflections. Only 11 directly referred to their future professional practice. **DISCUSSION**: Some themes emerged. This included consideration of capacity to apply spaceflight countermeasures to analogous terrestrial health conditions, and recognising the relevance of human space research to future career areas. There was thoughtful recognition of the value that both space exploration and space research can bring to improving life on Earth, including areas such as global health and food insecurity, and the impact of climate change. To build a better understanding of the unique context of the space sector, students progressively work through the NASA/LEGO 'Build to Launch' series and associated 'brainstorming' activities. In their reflections, students recognised many key qualities associated with successful space projects and missions, including teamwork, inter-disciplinary collaboration, flexibility, curiosity, creativity, innovation, resourcefulness, problem-solving skills and lateral thinking, lifelong learning, and research as a driver of best practice. These findings indicate that the 'space health' course creates multi-layered value and is achieving the relevant objectives.

Learning Objectives

1. Participants will learn about the approach to assessment for the University of Melbourne MD1 subject, "Human health in the space environment" and how this includes an element of student reflection on lessons from the course.
2. The audience will gain an understanding of two of the key course objectives for the subject and how well these have been achieved based on an analysis of student reflections.
3. Participants will leave with an appreciation of the key qualities associated with successful space projects and missions that were recognised by students in their reflections.

[455] BETHANECHOL AS A TREATMENT FOR ANTICHOLINERGIC-INDUCED URINARY RETENTION IN SPACE

Haig Aintablian
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(Education - Case Study)

INTRODUCTION: *Urinary retention (UR) is a critical medical concern that can and has been encountered by astronauts during space missions, especially given the use of anticholinergic medications for managing space motion sickness. Anticholinergics, although beneficial in mitigating motion-induced ailments, possess the downside of inhibiting bladder smooth muscle contractions, leading to UR. This scenario underpins the necessity of exploring potential countermeasures to ensure astronauts' health and mission success. Bethanechol, an older and relatively forgotten cholinergic agonist, is a promising candidate for addressing this issue, given its FDA approval for treating postoperative, postpartum urinary retention, and overflow incontinence on Earth.* **BACKGROUND:** *Existing literature elucidates Bethanechol's efficacy in counteracting anticholinergic-induced UR, particularly from medications like tricyclic antidepressants, neuroleptics, and anticholinergics, as highlighted in terrestrial medical texts. The primary benefit of Bethanechol's use in spaceflight over that of terrestrial applications is that it could significantly mitigate the need for urinary catheterization, a common intervention for UR, which carries a heightened risk of urinary tract infections, especially in the confined, microgravity environment of space. Medication management also alleviates the logistical and comfort challenges associated with catheter management on missions.* **CASE PRESENTATION:** *A healthy male had a documented overdose of Oxybutynin resulting in an anticholinergic induced UR. The individual suffered from multiple mild anti-cholinergic symptoms including dry mouth, dizziness, blurry vision, alongside developing UR. He was given 3L of fluids and developed symptoms of UR twice (2.5 hours apart). He refused catheterization both times. His UR was successfully reversed during both UR episodes with Bethanechol administration with symptom resolution within 24 minutes and without the need for catheterization. This highlights bethanechol as a therapeutic agent for anticholinergic-induced UR.* **DISCUSSION:** *This abstract investigates Bethanechol's efficacy in terrestrial cases of urinary retention, extrapolating its known benefits to microgravity conditions. This exploration could significantly contribute to developing a robust medical protocol for non-invasive management of UR, ensuring the well-being of crew, and consequently, the overall success of long-duration space expeditions.*

Learning Objectives

1. Understand the mechanism by which medication-induced urinary retention takes place.
2. Understand the infection risk associated with urinary catheterization in spaceflight.
3. Understand the utility of Bethanechol in the terrestrial environment and how to apply this to spaceflight.

[456] NOVEL EDUCATIONAL APPROACH IMPACTING FUTURE HUMAN SPACEFLIGHT ENGINEERS AND CLINICIANS

Alyvia O'Brien[1], Allison Anderson[1], Benjamin Easter[2], Arian Anderson[2]
[1]*University of Colorado Boulder, Boulder, CO, United States;*
[2]*University of Colorado-Aurora, Aurora, CO, United States*

(Education - Program/Process Review)

BACKGROUND: As human spaceflight rapidly expands with the progression of NASA's Artemis program and future missions to Mars, developing human spacecraft designs and operations that ensure crew survival and performance become essential to mission success. These developments require combined efforts from both engineers and physiologists; however, the training of each field results in varying language profiles and problem-solving strategies. Therefore, integrating engineering and physiological disciplines is necessary for creating successful human spacecraft and habitat designs that avoid serious consequences during mission operations. **OVERVIEW:** In response to this need, the University of Colorado Boulder's Medicine in Space and Surface Environments (MiSSE) course incorporates content from both engineering and medical disciplines in classes composed of aerospace engineering, bioastronautics, and integrative physiology undergraduate and graduate students. This course is taught both in the classroom and in a field simulation at the Mars Desert Research Station (MDRS) in Hanksville, Utah. Throughout the semester, students earn their wilderness medicine and CPR certifications, while developing a rocket and payload design to launch samples at MDRS. During the field portion, students perform simulated EVAs and learn fascinating topics taught by professors with varying backgrounds in emergency and aerospace medicine. The MiSSE course also recently introduced the Mars Emergency Clinic (MEC), a medical examination and treatment bay constructed by the University of Colorado Boulder MEDICS group, for MDRS simulations. We conducted a student survey to assess their adaptability to engineering- and medical-related challenges, as well as to monitor their prospective career goals prior to and following course completion. Qualitative analysis of the responses identified students' application of communication skills and problem-solving techniques (amongst others), and reflected a shift in interest to careers focusing on human interfaces in space. **DISCUSSION:** The MiSSE course successfully establishes and evaluates the integration of aerospace engineering and physiological disciplines demonstrated by the course's structure, composition, and student perspective. This course overall sparks inspiration and intellectual curiosity in the next generation of bioastronautics engineers and aerospace medicine physicians, a necessary step for future human spaceflight mission success.

Learning Objectives

1. Describe the unique facets of the Medicine in Space and Surface Environments course at the University of Colorado Boulder.
2. Understand the impact of a combined aerospace engineering and physiology curriculum on undergraduate and graduate students studying each discipline.

[457] NON-INVASIVE MONITORING OF HEART AND RESPIRATORY RATES USING A CELLPHONE-BASED APPLICATION DURING A SPACE ANALOG MISSION

Carlo Canepa, Dana Levin, Amit Padaki, Erik Antonsen
Baylor College of Medicine, Houston, TX, United States

(Original Research)

INTRODUCTION: Monitoring the vital signs of astronauts is important to mission success. Vital sign monitoring can often be invasive and obstruct activity. Obtaining an arterial waveform is particularly invasive. This technological demonstration aims to show non-invasive heart rate and respiratory rate monitoring through the use of a cellphone-based application and camera (Presage Health) in a remote setting. **METHODS:** The heart rate and respiratory rate of six adult analog astronauts (50% male, 50% female; ages 18-52) were measured using a cellphone-based application during a six day space analog mission at the HI-SEAS habitat (8200ft altitude) on Mauna Loa, Big Island, Hawaii. The heart and respiratory rates were compared to other data obtained simultaneously by traditional means (pulse oximeter and manually counted respiratory rate). The data were collected at rest, immediately after exercise, and after simulated extra-vehicular activity (EVA). **RESULTS:** The heart rate and respiratory rate of six adult analog astronauts were measured using a cellphone-based application and camera. Approximately 60 measurements were made over the course of 6 days (average 10/person). The data were accurate when compared to traditional means of measurement (pulse oximetry and manually counted respiratory rate). Some limitations of the applications included requiring sufficient ambient lighting, continuous face time, and internet service. **DISCUSSION:** This technology

demonstration shows that heart rate and respiratory rate can be successfully monitored non-invasively and accurately using a cellphone-based application and camera. Non-invasive cellphone-based monitoring of astronauts' vital signs can limit the use of cumbersome wiring and electrode placement. Strengths and limitations of this technology are discussed. This technology may be applicable in a variety of scenarios including austere environments, space stations, and lunar and Martian habitats.

Learning Objectives

1. This technological demonstration shows that heart rate and respiratory rate can be monitored non-invasively and accurately using a cellphone-based application and camera.
2. Cellphone-based monitoring of astronauts' vital signs can limit the use of cumbersome and invasive equipment.

[458] INCIDENCE AND RISK FACTOR ANALYSIS OF SPACE MOTION SICKNESS DURING STS AND ISS MISSIONS

Andrew Lam[1], Paul Porensky[2], Wafa Taiym[3]
[1]*Richmond Urgent Care, Richmond, VA, United States;* [2]*Naval Medical Readiness Training Command, San Diego, CA, United States;* [3]*KBR, Houston, TX, United States*

(Original Research)

INTRODUCTION: Inconsistent definitions of space motion sickness (SMS) across studies have muddied epidemiological descriptions of this operationally relevant condition. The cause of SMS also remains unclear, though some have suspected altered vestibular stimuli. We performed the largest-yet cohort study in US spaceflight operations to produce an updated estimate of SMS incidence and examine potential risk factors: spaceflight experience (naïve vs. non-naïve), launch vehicle (Shuttle vs. Soyuz), age (>50 vs. <50), and sex (male vs. female). **METHODS:** We generated a revised set of SMS symptom criteria based on pertinent literature review: "At least one primary symptom within 72 hours after microgravity exposure: stomach awareness, nausea, vomiting, malaise, anorexia, irritability, or loss of initiative. Dizziness, sweating, flushing, or pallor may accompany any primary symptoms. Coincident diarrhea excludes an SMS diagnosis." Records from Shuttle (STS) and International Space Station (ISS) missions, including crew debriefs, private medical conference (PMC) notes, and Space Medicine Operations Team (SMOT) notes, were coded by NASA Lifetime Surveillance of Astronaut Health (LSAH) for crew-reported symptoms and subjected to clinical text extraction (CTE) for SMS symptoms. The resulting data encompassed US crewmember missions from the STS program (1981-2011, n=644) and ISS Expeditions 1-62 (2000-2020, n=71), with exceptions like payload specialists. We coded each de-identified crewmember mission "Yes," "No," or "Ambiguous" for presence of SMS according to our symptom criteria, calculated overall SMS incidence, and determined relative and absolute risk for each variable of interest. **RESULTS:** Our investigation revealed that 61-66% of US crewmember missions developed SMS. Spaceflight naïve status ($P < 0.0001$), age <50 ($P < 0.05$), and Shuttle launch ($P < 0.01$) were positively associated with SMS. Sex showed no significant association. **DISCUSSION:** We confirmed that most astronauts experience SMS and identified risk factors that may support the vestibular hypothesis of SMS; non-naïve crew may be desensitized to the vestibular stimuli of microgravity, while the relative freedom of head movement in Shuttle over Soyuz vehicles may intensify such stimuli. Future studies can utilize our revised diagnostic criteria and findings to clarify pathophysiology or test mitigation techniques, which will likely prove indispensable for upcoming micro- and low-gravity expeditions.

Learning Objectives

1. Identify symptoms and objective measures of severity that are best included and excluded in a definition of space motion sickness.
2. Name risk factors that have and have not correlated with space motion sickness.

[459] PREDICTING PROCEDURAL NEEDS FOR CIVILIAN SPACEFLIGHT MISSIONS

Cong Wang, Sofia Fabrega, Eric Petersen, Kaleigh Stabenau, Ritwik Keshav
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(Original Research)

INTRODUCTION: Previously, as NASA screened astronauts, every candidate had undergone extensive medical examinations to ensure minimal potential for medical impacts on a mission. However, this will change as the commercial spaceflight industry grows and a more diverse population of individuals will journey into space. This study was designed to assess the surgical risk of different commercial mission profiles based on public health data standardized to the current commercial astronaut age demographic. **METHODS:** We collected demographic age data for commercial spaceflight participants from publicly available sources. We then utilized public data from the Healthcare Cost & Utilization Project (HCUP) for 2016-2019 to identify the incidence of different inpatient surgical operations based on total discharges. These rates were then standardized to the commercial astronaut age demographic. We assessed the frequency of emergent surgical events for two mission profiles: short-duration missions, e.g. the proposed VAST space station visits, and long-duration potential Mars missions, e.g. the SpaceX Starship missions. **RESULTS:** Demographic data for 53 civilian astronauts was collected. Mean age was 53.9 ± 17.4. 115 different procedures surpass 1% risk for long duration missions. The top 10 surgeries and their modeled risk for short and long duration missions were found to be knee arthroplasty (0.069%, 63.1%), hip arthroplasty (0.052%, 47.3%), Cesarean section (0.050%, 45.4%), spine fusion (0.036%, 32.1%), percutaneous coronary interventions (0.035%, 32.0%), cholecystectomy (0.021%, 19.1%), femur fixation (0.020%, 18.6%), colectomy (0.019%, 17.5%), coronary artery bypass grafts (0.015%, 13.4%), and arthroplasty of other joints (excl. knee/hip) (0.013%, 11.8%). **DISCUSSION:** We found that overall surgical risk for short duration commercial missions is low. However, long duration missions increase the risk of surgical need. Limiting the person-years with crew size or mission duration can help adjust surgical risk. National data may overestimate the risks due to the healthy worker effect. Many of these operations would not be currently possible due to launch limitations and current technology. Evaluating surgeries with >1% risk on long duration missions, preparation for trauma, abdominal emergencies, and soft tissue procedures should be included when designing commercial medical systems. Further studies will prioritize space-relevant emergencies.

Learning Objectives

1. To teach the audience the importance of anticipating an evolving landscape of astronaut demographics.
2. To show the audience how we approached modeling the risk of procedural events by employing national health data.

[460] HARD VACUUM CHAMBER TESTING OF COMMON MEDICATIONS IN SPACEFLIGHT

Kaleigh Stabenau[1], Megan Pendleton[2], Jaime Mateus[3], Amran Asadi[3]
[1]*University of Arizona College of Medicine-Phoenix, Phoenix, AZ, United States;* [2]*Stanford University, Stanford, CA, United States;* [3]*SpaceX, Hawthorne, CA, United States*

(Original Research)

INTRODUCTION: The effect of spaceflight on medication integrity has long been a subject of investigation. The effects of radiation, vibration, humidity variation, and packaging on physical and chemical stability of pharmacologic compounds have been assessed. Hard

vacuum testing of medications has been limited. When depressurization scenarios are considered, it becomes important to know what might happen to medications under these conditions in the event their use is required following vacuum exposure. **METHODS:** Twenty medications commonly supplied for spaceflight (e.g. acetaminophen, promethazine) were subjected to vacuum chamber testing within spaceflight packaging and storage bags at ambient temperatures and 0 C. Medication mass was determined before and after exposure to vacuum. Eight of the medications underwent mass spectrometry to determine if chemical signatures were altered by vacuum exposure. **RESULTS:** No gross physical changes were noted in any of the medications. The spaceflight packaging remained intact. The lowest temperatures were experienced inside the storage bags and the pressure stalled at 8.2e-3 and 6.0e-3 torr in the ambient temperature/0 C chambers, respectively; a finding attributed to endothermic off-gassing from packaging materials. There were no significant differences in the masses of 20 medications following exposure. There were also no differences in the mass spectrometry signatures of 8 medications following exposure. **DISCUSSION:** These results indicate that common medications used in spaceflight are stable in regards to mass and mass spectrometry signatures when exposed to hard vacuum. This is important when considering the possibility of medication use following a full cabin depressurization or if considering the use of a medical kit within an airlock. An area of future research involves the potential off-gassing of packaging materials when exposed to vacuum and how this might affect medication integrity over time. This study is limited by relatively small sample sizes and statistical power in addition to the inability to reach the goal pressure of 10^{-4} torr within the vacuum chambers.

Learning Objectives

1. There is no significant change in mass or mass spectrometric signatures of commonly used medications in spaceflight when exposed to near vacuum conditions.
2. Medications may be exposed to off-gassing from packaging or bags in vacuum.

[461] DEMOGRAPHIC DIFFERENCES AND IMPLICATIONS FOR HEALTH IN COMMERCIAL SPACEFLIGHT PARTICIPANTS COMPARED TO NASA ASTRONAUTS

Sofia Fabrega, Kaleigh Stabenau, Ritwik Keshav, Eric Petersen
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(Original Research)

INTRODUCTION: As the commercial spaceflight industry evolves, we should investigate potential differences in the diverse civilian population compared to NASA astronauts. With more civilians flying, in-flight medical risks may begin to trend toward standard population health risks. Our purpose was to compare the two populations and assess potential future commercial crew health risks. **METHODS:** We collected demographic data for both NASA astronauts and commercial spaceflight participants from publicly available sources. We then employed a t-test to assess differences in age and a chi-squared test to assess differences in sex. Next, we utilized public data from the Healthcare Cost & Utilization Project (HCUP) for 2016-2019 to identify the incidence rates of all diagnoses of emergency rooms visits in the US. These rates were standardized to the current commercial astronaut age demographic. The frequency of events for two mission profiles was assessed: short-duration missions akin to planned VAST space station visits and long-duration Mars missions modeled after SpaceX Starship missions. **RESULTS:** Mean age of civilian astronauts was 53.9 ± 17.4 years-old and 43.7 ± 6.3 years-old for NASA astronauts ($p<0.01$). Male to female ratios were not statistically significantly different. The most common diagnoses and their modeled risk on short and long duration missions were: nonspecific chest pain (0.713%; 659%), UTI (0.425%; 769%), superficial injury (0.484%; 734%), abdominal pain (0.672%;722%), septicemia (0.310%, 652%), MSK pain (0.514%; 613%), heart failure (0.203%; 556%), sprains/strains (0.468%; 468%), respiratory symptoms (0.274%; 410%), skin infections (0.345%; 406%). **DISCUSSION:** We found that the current NASA astronauts are significantly younger than civilian astronauts whereas civilian astronauts have a greater age range. Modeling this population's health risk suggests short duration missions are low risk for medical emergencies. However, for long duration missions we should prepare for injuries, infections, and cardiovascular events. Mission designers can limit risk by adjusting crew size and duration. Modeling commercial astronaut risk with standard population health data may help in the design and implementation of inclusive healthcare strategies that ensure the safety and well-being of all space travelers. Future studies will further stratify based on ICD-10 codes.

Learning Objectives

1. To teach the audience the importance of anticipating an evolving landscape of astronaut demographics.
2. To show the audience how we approached modeling the risk of medical events in-flight by employing national health data.

[462] CHRONOBIOLOGY OF GALACTIC COSMIC RAY EXPOSURE: ROLE OF CIRCADIAN RHYTHMS IN DNA DAMAGE RESPONSES, CARCINOGENESIS, AND COUNTERMEASURES FOR SPACEFLIGHT

Nicolas Nelson
UCLA, Los Angeles, CA, United States

WITHDRAWN

[463] OBJECTIVE MEASUREMENT OF EUSTACHIAN TUBE DYSFUNCTION TO DECREASE BAROTRAUMA RISK

Milad Dulloo[1], Martin Robinette[2]
[1]*University of Lausanne, Lausanne, Switzerland;* [2]*UTMB, NASA JSC, Houston, TX, United States*

(Education - Program/Process Review)

INTRODUCTION: Astronauts experience pressure fluctuations while diving, flying and during extra-vehicular activities (EVA). These activities require an ability to equalize the middle ear (ME). The Eustachian tube's (ET) function is ventilating the ME to balance pressures with the ambient atmosphere. Eustachian Tube Dysfunction (ETD) is impaired ventilatory function of the middle ear. It is divided in three subtypes, dilatory (non-opening), baro-challenge induced and patulous (abnormally open). ETD increases the risk of barotrauma which can impact the crewmember's health and mission. ET function varies between individuals and different times due to intrinsic and extrinsic factors. Microgravity and cephalic fluid shift may favor ETD via nasal congestion and swelling of nasopharyngeal tissue. An objective tool to assess the risk of ETD is needed. We propose ETD screening using tympanometry to identify crewmembers with high-risk of barotrauma, ensuring astronauts safety during training and missions. **METHODS:** The physiopathology and etiology of ETD were reviewed. Existing diagnostic tools were evaluated for efficiency and ease of use in a preventive setting. We identified adequate tympanometry tests for screening and defined pass and fail criteria. Three protocols assessing ETD risk pre-dive, pre-flight and pre-EVA were established. Tympanometry data from 28 astronauts was extracted and analyzed to identify current trends. **RESULTS:** Tympanometry is an optimal tool to assess ET ventilatory function. Three relevant tests were identified as well as criteria for screening ETD risk. Resting ME pressure test is an effective tool pre-EVA and pre-flight. The post-deflation test is a reliable to identify high-risk pre-flight. Post-Valsalva and Nine-Step tests are useful pre-dive. Current astronaut data shows a significant number of measures in the high-risk range. Majority of crew is within low-risk range, but several others are in the higher risk. **DISCUSSION:** Data suggest a significant proportion of crewmembers have increased risk. Protocols for pre-dive, pre-flight and pre-EVA screening are recommended to reduce the risk of barotrauma and mission failure. Further research is needed to collect objective data and evaluate risk parameters.

Learning Objectives
1. Function of the ET, and barotrauma risk associated with its dysfunction.
2. Risks of barotrauma in NASA activities and recommendations for preventive risk assessment.

[464] EXPERIMENTAL DESIGN FOR RADIONUCLIDE X-RAY IMAGING IN SPACEFLIGHT

Tejal Gala[1], John Choi[2], Saif Azam[2], Matthew Hartman[2], Max Raynor[2], Scott Fraser[2]
[1]*Keck School of Medicine of the University of Southern California, Los Angeles, CA, United States;* [2]*University of Southern California, Los Angeles, CA, United States*

(Original Research)

INTRODUCTION: Long-term manned spaceflight, such as to Mars, will require inflight medicine, including inflight diagnostic space radiology. Currently, ultrasound is the only imaging modality available inflight, but technical factors limit evaluation through bone or gas, such as for intracranial, pulmonary, or gastrointestinal pathologies. For this reason, X-ray based imaging is necessary, but it has not been utilized due to limited onboard spacecraft resources, such as power. We propose a radionuclide X-ray source to reduce the power requirement, coupled with a digital camera in contrast to prior demonstrations using X-ray film, as an ideal experimental platform for a flight demonstration. **METHODS:** Commercially available exempt quantity radionuclides were coupled with a digital camera using a phosphor screen to convert X-rays to visible photons. The experimental apparatus was built using commercially available lens tube parts connected to the camera via the lens mount. Image subjects included tungsten foil and a tissue sample (cooked meat). Different sources and imaging conditions were examined. **RESULTS:** Three radionuclides were evaluated: Barium-133, Cadmium-109, and Cesium-137. Different amounts of contrast were demonstrated and correlated with the emission spectrum of each radionuclide. Imaging parameters were adjusted to optimize exposure. Optimal exposure time for the tungsten sample was approximately 15 minutes for all three sources but varied for the tissue sample: 15 minutes for Cesium, 10 minutes for Cadmium, and 5 minutes for Barium. **DISCUSSION:** The study demonstrated that it is possible to create a compact, lightweight, low-power, radionuclide-based X-ray imaging system that could be used in a flight demonstration. Further work is required to optimize the images, such as uniformity correction due to the low photon flux levels and short distance from source to sample. While the images obtained are far from clinical diagnostic quality, they are radiographs and demonstrate a feasible path to a flight instrument. In addition to diagnostic space radiology, inflight X-ray imaging is expected to enable minimally invasive interventional procedures, as well as cross-sectional imaging of humans in space for scientific purposes.

Learning Objectives
1. Understand the components of an X-ray imaging system and how to utilize a phosphor screen and radionuclide to create a compact, low-power experimental platform for a flight experiment.
2. Understand the criteria used to evaluate a radionuclide for X-ray imaging.

[465] USING A HUMAN SYSTEM FAILURE MODEL AS AN ALTERNATIVE APPROACH TO MEDICAL PLANNING FOR HUMAN SPACE EXPLORATION MEDICAL SYSTEMS

Muska Miller[1], Veronika Puisa[1], Thomas G. Smith[1], Peter Hodkinson[1], Sergi Vaquer[2]
[1]*King's College London, London, United Kingdom;* [2]*ESA, Cologne, Germany*

(Education - Tutorial/Review)

INTRODUCTION: Human exploration missions e.g. the Lunar Gateway require capabilities necessary to sustain crew life for up to 60 days. Identification of medical risks to inform development of appropriate medical kits has traditionally been an important activity for mission planners and spacecraft design engineers because resources and space are so limited and naturally require prioritization. Traditional medical planning approaches have been based on specific knowledge of environmental hazards e.g. microgravity, radiation, isolation and confinement, and anticipated medical risks. These probabilistic approaches take input on the likelihood of occurrence of medical issues based on e.g. past spaceflight experience and terrestrial analogues to generate medical kits able to respond to predicted medical issues. Alongside these well founded and proven approaches, the European Space Agency (ESA) is keen to explore alternatives that will complement these methodologies by providing a parallel way of thinking. ESA is specifically exploring an approach based on human system failures. **TOPIC:** This alternative approach to medical planning will be presented that explores the common pathways of human system failures (e.g. cardiovascular, respiratory, neurological etc), and the application to spaceflight. This includes how these might occur, the threat they may pose to life or mission, and, the associated diagnostic and treatment commonalities, to generate the medical kit list. These medical kits can then be compared with and tested against those generated from the probabilistic models. By merging the approaches along with expert input, the aim is to provide an opportunity to continue the evolution and improvement in medical planning and kits for exploration missions. **APPLICATION:** Using this human system failure model, life-threatening and non-life-threatening failure modes were identified, along with specific diagnostic tools and management therapies. This information was used to identify common elements to inform the development of a medical emergency kit equipped to treat the diversity of human failure modes, which is irrespective of the underlying diagnosis. The proposed medical kit has been evaluated by healthcare professionals across a range of specialties, including those with pre-hospital experience. Follow up work will include assessment in an analogue environment to test its efficacy and help identify areas for improvement.

Learning Objectives
1. Traditional medical planning approaches are probabilistic and use past spaceflight experience and terrestrial analogues to generate medical kits to respond to predicted medical issues.
2. Human system failures, how these might occur and the threat posed to life or mission, may be used as a complementary method when generating medical kits for spaceflight.

Thursday, 05/09/2024 ***1:30 PM***
Grand Ballroom A

[S-79]: PANEL: WHERE ARE WE WITH WHITE MATTER AND HYPOBARIA? LATEST RESEARCH AND OUTCOME OF NATO COLLABORATION

Chair: Desmond Connolly
Co-Chairs: Joan Saary, Paul Sherman

PANEL OVERVIEW: *An association between excess subcortical white matter hyperintensities (WMH) and non-hypoxic hypobaria was first reported over a decade ago. NATO Research Technology Group 274 (RTG 274) convened in 2016 to provide a focus for research collaboration and information exchange regarding risks of hypobaric exposure, with emphasis on pathophysiology of WMH. The panel will summarise the latest international research and conclusions of RTG 274 in its recent final report. First, the US research over the last decade will be reviewed, with emphasis on U-2 pilot white matter health, tract integrity (fractional anisotropy) and cognitive performance, and WMH burden in aerospace operational physiologists. A miniature swine model suggests arrest of myelination but possible neuroprotective (anti-oxidant/anti-inflammatory) benefit of atorvastatin. Next, two UK presentations will detail acute human pathophysiological responses to*

severe decompression stress (simulated high altitude parachutist despatch). Besides systemic pro-inflammatory responses, blood biomarkers of brain and lung insult indicate abrupt neuro-inflammatory responses with subsequent neurotrophic changes evident the next day. Acute magnetic resonance imaging (MRI), the day after hypobaric exposure, indicates altered subcortical white matter neurometabolite concentrations indicating loss of neuroprotection, while appearance of lactate and upregulation of white matter blood flow imply preceding microvascular insult. Following on, recent research involving Royal Canadian Air Force fast jet pilots will be presented, encompassing prevalence and volumetric analysis of WMH, blood biomarkers, and neurocognitive evaluation. WMH burden is significantly elevated in fast jet pilots relative to age-matched controls, while regular occupational exposure to non-hypoxic hypobaria may promote ongoing low-grade systemic inflammation with evidence of chronically increased oxidative stress. International evidence supports neuroinflammatory changes in response to hyperoxic decompression, possibly associated with underlying microvascular dysfunction and oxidative stress. Finally, the audience will be updated with the most recent US research into persistent cerebral blood flow responses after hypobaric hypoxia training. Further work will be required to elucidate the neuropathological processes associated with the development of white matter change, appropriate exposure thresholds and effective pharmaceutical interventions.

[466] REVIEW OF THE EFFECTS OF EXTREME HYPOBARIC ENVIRONMENTS UPON THE BRAIN IN AVIATORS AND HIGH-ALTITUDE SPECIAL OPERATORS IN THE PAST DECADE

Paul Sherman

Defense Health Agency/59th Medical Wing, Joint Base San Antonio-Lackland, TX, United States

(Original Research)

INTRODUCTION: NATO HFM ET-138 (2015) followed by HFM RTG-274 (2016-2023) addressed the effects of high altitude upon the brain in pilots and special operators. The last decade of human and swine research of RTG-274 will be reviewed. **METHODS:** Review of the 16 published manuscripts, recently completed research, and the final report of RTG-274, encompassing both human and swine studies. **RESULTS:** There are both transient and permanent changes in the brain secondary to acute and chronic-repetitive hypobaric exposure. U2 pilots demonstrate increased white matter hyperintensities (WMH), global decrease in white matter integrity as measured by magnetic resonance imaing (MRI) fractional anisotropy (FA), and mild neurocognitive deficits (microcognitive testing) compared to age-matched pilot controls. Post cabin altitude reduction effort (CARE) longitudinal MRI evaluation of U2 pilots every three years has shown no significant change in WMHs from initial brain MRI upon entering the U-2 assignment. Single exposure to high altitude (hypobaric chamber training) demonstrates an approximately 5-6% increase in cerebral blood flow (CBF) to whole brain white matter that persists for 72 hours. Repeated high-altitude exposure (6-12 flights) in teenage equivalent swine (Sinclair minipigs, age determined by weight requirements to fit in the MRI coil) results in transient metabolite changes as measured by MR Spectroscopy and an arrest in myelination (global decreased FA) compared to control animals. Subsequent swine high altitude exposure with and without Atorvastatin (a flying waiver approved statin with antioxidant/anti-inflammatory properties) demonstrated significant differential expression of mRNA suggesting potential neuroprotective effects. **CONCLUSION:** The hypobaric exposure environment will remain an essential domain for NATO operations. Unanimous concern for understanding the pathophysiology of hypobaric exposure related brain injury in our aircrew and special operations personnel remains. Further study is required and is underway, with the aim of finding potential mitigators of altitude related "brain stress."

Learning Objectives

1. Understand the current body of research related to transient and permanent brain injury related to hypobaric exposure operations, results of the NATO HFM RTG-274.
2. Understand the current neuropathophysiological hypotheses related to high-altitude brain injury.

[467] BRAIN BIOMARKER RESPONSES TO NON-HYPOXIC HYPOBARIA

Desmond Connolly[1], Leigh Madden[2]

[1]*QinetiQ plc, Farnborough, United Kingdom;* [2]*University of Hull, Hull, United Kingdom*

(Original Research)

INTRODUCTION: Laboratory evaluation of decompression sickness (DCS) risk with repeat exposure to 25,000 ft pressure altitude enabled investigation of brain biomarker responses to non-hypoxic decompression stress. Targets included markers of neuroinflammation, neural injury, repair and degeneration, and blood-brain barrier integrity. **METHODS:** Fifteen healthy men (20 to 50 yrs) undertook consecutive hypobaric chamber ascents to 25,000 ft pressure altitude, breathing 100% oxygen. Venous plasma and serum samples, collected at baseline (T0), following ascent two (T8) and next day (T24), indicated a systemic pro-inflammatory response with levels of glial fibrillary acidic protein (GFAP) increasing by 10% over baseline at T24 ($P = 0.015$). Residual sample material allowed selected follow-on brain and lung biomarker assays using enzyme-linked immunosorbent assay (ELISA) for soluble proteins and flow cytometry for microparticles (MPs). **RESULTS:** Biomarkers of brain injury (neurofilament light; ubiquitin carboxy-terminal hydrolase L1), neurodegeneration (tau protein), oxidative stress (brain creatine kinase) and alveolar injury (CD324 and CD326 MPs) were unremarkable. At T8, monocyte chemoattractant protein-1 (MCP-1) levels rose by 36% ($P = 0.005$) and high mobility group box protein 1 (HMGB1) by 16% ($P = 0.046$), both normalising at T24. Brain-derived neurotrophic factor (BDNF) was elevated by 80% ($P = 0.029$) at T24. Soluble receptor for advanced glycation end products (RAGE) fell by 8% at T8 before normalising ($P = 0.032$). Mean HMGB1/RAGE ratio increased by ~30% at T8 ($P < 0.01$). Post-exposure monocyte counts increased 37% and CD14 (monocyte-derived) MPs were elevated disproportionately ($P = 0.032$). **DISCUSSION:** Post-exposure elevation of MCP-1 and HMGB1 support an acute neuroinflammatory response, with increased GFAP and BDNF indicating trophic responses to glial stress at T24. Increased circulating monocytes, elevated CD14 MPs, and raised MCP suggest a key role for monocytes in mediating the neuroinflammatory response. These data are consistent with subcortical microvascular insult and reports of macrophage accumulation in areas of acutely inflamed white matter microvasculature stressed during decompression. Additionally, monocyte activation and stimulation of the HMGB1-RAGE axis will both generate interleukin-6 and may contribute to the systemic pro-inflammatory response reported previously.

Learning Objectives

1. Understand the acute brain biomarker responses that suggest a neuroinflammatory response to hyperoxic decompression stress.
2. Understand the brain biomarker responses that suggest a neurotrophic (repair) response following hyperoxic hypobaria, implying recovery from glial (white matter) insult.

[468] ACUTE RESPONSES TO NON-HYPOXIC HYPOBARIA ON BRAIN MAGNETIC RESONANCE IMAGING

Desmond Connolly[1], Indran Davagnanam[2]

[1]*QinetiQ plc, Farnborough, United Kingdom;* [2]*University College London, London, United Kingdom*

(Original Research)

INTRODUCTION: Investigation of decompression sickness (DCS) risk with repeated (same-day) exposure allowed evaluation of acute brain magnetic resonance imaging (MRI) indicators of neurological stress in response to non-hypoxic hypobaria. Brain MRI sequences evaluated subcortical white matter (WM) integrity, WM tract diffusivity, cerebral blood flow and neurometabolite concentrations. **METHODS:** Six healthy men (20 to 50 yrs) undertook three ascents, each lasting two hours, to a

maximum 25,000 ft pressure altitude, breathing 100% oxygen throughout. Consecutive ascents followed an hour at ground level breathing air. Brain MRI sequences conducted on the days preceding and following decompression encompassed: diffusion-weighted imaging (DWI) to exclude subcortical micro-infarcts, ischaemia and oedema; diffusion tensor imaging (DTI) for WM tract integrity (fractional anisotropy, FA); arterial spin labelling (ASL) for global grey matter (GM) and WM blood flow; and magnetic resonance spectroscopy for neurometabolite concentrations in parietal subcortical WM, GM (putamen) and cerebellum. **RESULTS:** Post-exposure DWI imagery remained normal, with no subcortical micro-infarcts, ischaemia or oedema. FA was unaffected with near identical pre- and post-exposure profiles in all individuals and the cohort as a whole. In subcortical WM, post-exposure levels of γ-amino butyric acid (GABA) and glutathione fell by 19% ($P = 0.021$) and 27% ($P = 0.049$) respectively, whilst lactate increased in five participants. Neurometabolites in GM and cerebellum were unaffected. Cohort WM blood flow increased and approached the upper limit of MRI estimates, while GM flow was essentially unchanged. **DISCUSSION:** Post-exposure decrements in subcortical GABA and glutathione correlate well ($R^2 = 0.69$, $F(1,4) = 8.82$, $P = 0.041$), suggesting a common origin and loss of neuroprotection. The appearance of lactate implies anaerobic metabolism despite imposition of hyperoxia, possibly from macrophage accumulation in areas of acutely inflamed WM microvasculature stressed during decompression. This is consistent with upregulation of WM flow, which also mitigates and predicts the decrement in glutathione at 24 hours ($R^2 = 0.74$, $F(1,4) = 11.37$, $P = 0.028$). The data provide evidence of acute WM stress following hyperoxic decompression, supporting blood biomarker data, and may help to inform the aetiology of white matter change associated with occupational non-hypoxic hypobaric exposure.

Learning Objectives

1. Understand the influence of hyperoxic decompression stress on subcortical white matter neurometabolite concentrations and how they suggest loss of neuroprotection, oxidative stress and microvascular insult.
2. Understand the cerebral white matter blood flow response to hyperoxic decompression stress and how this influences understanding of microvascular responses to hyperoxia.

[469] FIGHTER PILOTS HAVE ELEVATED WHITE MATTER HYPERINTENSITIES ON MRI – BUT WHY?

Joan Saary[1], Joel Ramirez[2], Christopher Scott[2], Fuqiang Gao[2], Shawn Rhind[3], Oshin Vartanian[3], Gary Gray[4], Shamus Allen[5], Sandra Black[2]

[1]*University of Toronto and Canadian Forces Environmental Medicine Establishment (CFEME), Toronto, ON, Canada;* [2]*Sunnybrook Research Institute, Toronto, ON, Canada;* [3]*Defence Research and Development Canada - Toronto, Toronto, ON, Canada;* [4]*Canadian Forces Environmental Medicine Establishment, Toronto, ON, Canada;* [5]*University of Calgary, Calgary, AB, Canada*

(Original Research)

INTRODUCTION: Contributing to the international research effort to understand the clinical and occupational relevance of white matter hyperintensities (WMH) in aircrew, The Canadian White Matter Hyperintensity study used MRI brain imaging to quantify WMH in Royal Canadian Armed Forces (RCAF) fighter pilots. We previously (2021) presented preliminary results suggesting higher than expected WMH volumes for age. Reanalysis of the now-complete data set supports the hypothesis that fighter pilots have elevated WMH volumes. **METHODS:** After protocol ethical approval by the Research Ethics Boards of Defence Research and Development Canada (DRDC) and Sunnybrook Health Sciences Centre, 42 volunteer pilots with experience flying high performance aircraft and 6 experienced high altitude (non-pilot) parajumpers attended 2 days of testing that included questionnaires on exposure history and known correlates of WMH; physical exam; cognitive testing; blood sampling for peripheral biomarkers; cardiac risk markers; and an agitated saline contrast echo. All underwent brain imaging using a 3 Tesla (T) scanner. Log books provided data on total flight hours and flight hours on specific aircraft types. **RESULTS:** As expected, total WMH volume was significantly correlated with age (r=.48 p<.01). Pilots aged ≤55 had significantly greater WMH volume than age-matched controls (321.9mm^3 vs. 158.6mm^3, p=.005). Jumpers had significantly more WMH burden than pilots (691mm^3 vs. 470mm^3, p=.024), but also had more prior traumatic brain injuries (tbi) (67%) than pilots (40.5%) in whom elevated WMH volume was not tbi-related. In pilots aged ≤55, WMH was elevated occipitally vs controls (122.0 mm^3 vs 37.2mm^3 p=.005) and was correlated with total flight time (r=.411, p<0.05) but not high-performance hours. In the total pilot sample, high-performance time, but not total flight time, was correlated with peri-vascular space volume (r=.352, p< 0.05) but not WMH volume. **DISCUSSION:** Earlier suspicion that WMH burden is elevated in this pilot population is reconfirmed. We continue to examine possible explanatory factors and will discuss our suspicion that a more nuanced examination of flight time on specific aircraft may provide clues to the underlying processes making this population susceptible to increased WMH load. Next steps will also include examining the clinical neurocognitive relevance of these findings.

Learning Objectives

1. The participant will learn about the updated analytics for the Canadian White Matter Hyperintensity Study and the results thereof.
2. The audience will utilize information from the presentation to participate in hypothesis-generating relating to why WMH burden is elevated in fighter pilots.

[470] WARFIGHTER BRAIN HEALTH IN HYPOBARIC ENVIRONMENTS POST NATO HFM RTG-274

Paul Sherman

Defense Health Agency/59th Medical Wing, Joint Base San Antonio-Lackland, TX, United States

(Original Research)

INTRODUCTION: Hypobaric hypoxia (HH) negatively impacts neurocognitive performance. This presentation will address the current human research efforts regarding cerebral blood flow (CBF) changes and swine research efforts to identify drugs and small molecules that can address biomedical impacts of high-altitude flight based on mRNA and miRNA signatures obtained from miniature swine high-altitude models. **METHODS:** A subset of 32 participants from our original study (161 subjects; 96 aircrew trainees, 65 control subjects) and subjected to new analyses. Each subject was exposed to HH at 25,000 ft (7620 m) in altitude chambers by removing their aviator masks for 2-4 minutes. MRI was acquired 24-hr prior to HH and follow-up MRI was conducted 24-hr and 72-hr post-exposure. MRI included pseudo-continuous arterial spin labeling (pcASL) and T1-weighted imaging. Standard space perfusion maps were compared with baseline maps in a VA fashion using paired t-tests. We utilized ARDIS cloud computing for construction and remixing of knowledge graphs (KG) targeted for drug repurposing and application of modern machine learning algorithms to generate a ranked list of relevant small molecules. We utilized a graph machine learning model to predict drug – miRNA interactions and developed a visualization component that displays nodes of interest and their relationships in the KG. **RESULTS:** There were significant increases from baseline CBF at both the 24-hr and 72-hr post-exposure scans in the midline, putamen, and near Sylvian/peripheral arteries. The effect is variable across individuals, with some perfusion changes approaching 10% which persist for 3 days after a single hypoxic exposure. 36 links were predicted between drugs and any of differentially expressed swine genes and human homologs in high-altitude conditions. Classes of the 36 identified drugs included statins, MG-CoA reductase inhibitors, anti-cancer/neoplastic drugs, and anti-infective drugs. **DISCUSSION:** Analysis indicates the increased WM CBF effects specific regions of the brain, demonstrating the importance of both global (ROI) assessments of CBF as well as VA to detect altered CBF following HH, enhancing our understanding of cerebral hemodynamics

associated with HH. The next steps to validate drug predictions will be in vitro/in vivo studies with identified small molecules or retrospective analysis of clinical data sets to confirm therapeutic effects.

Learning Objectives

1. Understand the need for additional research regarding the neuropathophysiology of brain injury related to repeated hypobaric exposure.
2. Understand research lines of effort in progress to mitigate the effects of high altitude exposure upon the brain.

Thursday, 05/09/2024 ***1:30 PM***
Grand Ballroom B

[S-80]: PANEL: ASAMS AEROSPACE MEDICINE 2024 BOARD REVIEW PANEL

Chair: Jeffrey Jones
Co-Chairs: Dwight Holland, Jim Elliott

PANEL OVERVIEW: *To assist American Society of Aeromedical Specialists members in preparing for initial or periodic written examinations for those educated on the topics defined by the American College of Preventive Medicine GME requirements and wishing to become certified or re-certified under the American Board of Preventive Medicine; and to provide education on relevant topics for those interested in Aerospace and Preventive Medicine, the ASAMS education committee assembles topics for review by knowledgeable invited experts in the field. TOPICs: Introduction to the Aerospace Medicine Board Exam Aerospace Physiology Alcohol/Fatigue, Situation Awareness, and Human Factors Analysis and Classification System ('HFACS') Flight Environment Example Test Questions APPLICATION: The knowledge gained in this panel can be applied by the attendee to preparation for the knowledge examination in both the preventive medicine core and the aerospace medicine specialty examination. Others considering potential involvement in clinical Aerospace Medicine or aerospace medicine relevant research may find the review topics interesting and educational. Preventive Medicine Core Content Outline: 25% - I. Clinical Preventive Medicine 25% - II. Public Health/Population Health Medicine Knowledge 20% - III. Epidemiology, Biostatistics, and Informatics Knowledge 15% - IV. Environmental Medicine 15% - V. Strategic Healthcare Leadership Knowledge Aerospace Medicine Content Outline: 40% - The Flight Environment 30% - Clinical Aerospace Medicine 20% - Operational Aerospace Medicine 10% - Management and Administration*

[471] ASAMS AEROSPACE MEDICINE 2024 BOARD REVIEW PANEL

Jeff Jones[1], Thomas Jarnot[2], James Elliot[3], Dwight Holland[4], Joseph Novak[5]
[1]*Baylor College of Medicine, Houston, TX, United States;* [2]*Civilian U.S. Air Force Materiel Command, USAFSAM/FEEG, Dayton, OH, United States;* [3]*FAA, Fort Worth, TX, United States;* [4]*Aerospace Consulting, Roanoke, VA, United States;* [5]*U.S. Air Force, Dayton, OH, United States*

(Education - Tutorial/Review)

INTRODUCTION: To assist American Society of Aeromedical Specialists members in preparing for initial or periodic written examinations for those educated on the topics defined by the American College of Preventive Medicine GME requirements and wishing to become certified or re-certified under the American Board of Preventive Medicine; and to provide education on relevant topics for those interested in Aerospace and Preventive Medicine, the ASAMS education committee assembles topics for review by knowledgeable invited experts in the field. **TOPICs:** Introduction to the Aerospace Medicine Board Exam

Aerospace Physiology

Alcohol/Fatigue, Situation Awareness, and Human Factors Analysis and Classification System ('HFACS')

Flight Environment

Example Test Questions

APPLICATION: The knowledge gained in this panel can be applied by the attendee to preparation for the knowledge examination in both the preventive medicine core and the aerospace medicine specialty examination. Others considering potential involvement in clinical Aerospace Medicine or aerospace medicine relevant research may find the review topics interesting and educational.

Preventive Medicine Core Content Outline:

25% - I. Clinical Preventive Medicine
25% - II. Public Health/Population Health Medicine Knowledge
20% - III. Epidemiology, Biostatistics, and Informatics Knowledge
15% - IV. Environmental Medicine
15% - V. Strategic Healthcare Leadership Knowledge

Aerospace Medicine Content Outline:

40% - The Flight Environment
30% - Clinical Aerospace Medicine
20% - Operational Aerospace Medicine
10% - Management and Administration

RESOURCES: American Board of Preventive Medicine – American Board of Preventive Medicine – The American Board of Preventive Medicine was established to promote the health and safety of the American people through our high standards in the certification and maintenance of certification in the profession of preventive health. (theabpm.org)

American College of Preventive Medicine- American College of Preventive Medicine | ACPM

Learning Objectives

1. To improve the understanding of human factors involved in the operation of aviation and space vehicles, and the key elements of the human-machine interface which can affect both operability and performance, e.g. Alcohol/Fatigue, and Situation Awareness; plus explanation of the Human Factors Analysis and Classification System ('HFACS').
2. To familiarize the audience with an understanding of key principles of aerospace physiology and the impact of the dynamics on the vehicle/aircraft flight crew.
3. To outline the important elements of the flight environment which influence flight dynamics and affect human health and crew performance.

Thursday, 05/09/2024 ***1:30 PM***
Grand Hall J

[S-81]: SLIDES: AEROSPACE MEDICINE RESEARCH

Chair: Joanna Nelms
Co-Chair: Steven Roy

[472] AEROSPACE MEDICINE EDUCATION AT A COMMERCIAL SPACE COMPANY

Isaiah Reeves[1], John Marshall[2]
[1]*UTMB, Galveston, TX, United States;* [2]*Hercules Medical Group, LLC, Houston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: The growing field of commercial human spaceflight includes novel considerations for the aerospace medicine specialist. These include the aeromedical evaluation of individuals from diverse backgrounds and with a wide array of medical conditions, as well as understanding key stakeholders and operational goals of the commercial spaceflight company. With this in mind, aerospace medicine resident education through commercial space companies provide broad benefit to future flight surgeons and aerospace medicine specialists. **OVERVIEW:** University of Texas Medical Branch aerospace medicine residents have

opportunities to rotate at Axiom Space and complete projects under the guidance of an Axiom flight surgeon. One particular experience involved leveraging preventive medicine principles in the evaluation and analysis of current infectious disease and public health threats as part of a developing pre-launch health stabilization program. The experience involved data-gathering and stakeholder analysis including considerations for participation of commercial spaceflight to the International Space Station, as well as considering future implications for end-to-end commercial missions. **DISCUSSION:** This learning opportunity highlighted some of the unique considerations of the conduct of human spaceflight and aerospace medicine as part of a commercial space company. By contributing directly to discussion and development of a knowledge base and program at the commercial company, this experience not only provided real-time benefit to the company but also gave essential exposure to the duties of commercial space flight surgeons and thus increased future competence.

Learning Objectives

1. The participant will understand the expanded and specific learning opportunities possible for aerospace medicine residents at commercial space companies.
2. The participant will understand the importance of integrated aerospace medicine resident education at commercial space companies for future employee competence.
3. The participant will understand the mutual benefits for aerospace medicine resident and commercial space companies when commercial space companies integrate supervised and mentored aerospace medicine education.

[473] OPERATIONALLY-FOCUSED AEROMEDICAL RISK MANAGEMENT FRAMEWORK: A NEW ERA IN RISK MANAGEMENT FOR RAAF.

Adrian Smith, Riannon Quemard
RAAF Institute of Aviation Medicine, Adelaide, Australia

(Education - Program/Process Review)

BACKGROUND: The health of aircrew and controllers is an integral component of aviation safety. The traditional role of the Institute of Aviation Medicine (IAM) was to restrict crewmembers believed to pose an unacceptable risk to aviation safety. However, this was conducted using a framework and language unfamiliar to Commanders. As Defence pivoted towards a balanced Command-acceptance of risk, the traditional model was seen as conservative, risk-averse, and overly-restrictive, and there was a drive for aeromedical risk to align with the management of other risks. **OVERVIEW**: This presentation outlines the process adopted by IAM to assess the likelihood of an aeromedical event occurring during aviation-related duty and result in an adverse outcome, and the controls to eliminate or minimise the aeromedical hazard in a shared model to inform Command-acceptance of risk. **DISCUSSION**: Australian Work Health and Safety (WHS) legislation imposes a duty of care on Chief of Defence Force to ensure the health and safety of workers. Commanders have a responsibility to be informed of the risks and all possible controls associated with any hazards, and if it is not reasonably practicable to eliminate the hazard, to ensure the risks are minimised so far as reasonably practicable. The Australian Defence Force (ADF) has adopted the Seven Step Risk Process (7SRP) as the basis for a harmonised risk management process. IAM has adopted the 7SRP as the basis of the novel Operationally-Focussed Aeromedical Risk Management framework (OFARM) to communicate aeromedical hazards in a manner that complements the approach to other risks potentially impacting aviation safety. The assessment of likelihood and consequences arising from an aeromedical event are shared between the aeromedical advisor, domain experts, and Commanders. Commanders have final authority regarding authorisation of personnel to perform aviation-related duties, with the aeromedical advisor responsible to ensure they have been informed of the hazards and credible adverse outcomes, and that all possible controls have been considered. A Risk Decision Brief documents the basis for this decision process. The OFARM is a significant evolution in aeromedical risk management. By aligning aeromedical risks with other aviation-related risks, aeromedical risks can be communicated in a format Commanders are familiar with, leading to better engagement between aeromedical and operational domains.

Learning Objectives

1. The audience will learn about the novel approach developed by RAAF IAM to assess and manage aeromedical risk in line with the 7 Step Risk Process.
2. The audience will understand the difference between traditional model of aeromedical risk management and contemporary risk-management where risk acceptance is a command responsibility rather than a medical responsibility.

[474] DISCUSSION OF HIV DISCLOSURE PROCESS AND RELATED POLICY

Robert Barbera
USAFSAM, San Antonio, TX, United States

WITHDRAWN

[475] REVIEW OF THE NATURAL HISTORY OF RENAL STONES IN U.S. ASTRONAUTS

Clare McNerlin[1], Sara Mason[2], David Reyes[3]
[1]*Georgetown University, Washington, DC, United States;* [2]*KBR, Houston, TX, United States;* [3]*NASA JSC, Houston, TX, United States*

WITHDRAWN

[476] EVOLUTION OF SPACEFLIGHT RENAL STONE RISKS AND UPDATE TO THE NASA RENAL STONE EVIDENCE REPORT AND INTEGRATED CONCEPT OF OPERATIONS

Emily Stratton[1], David Reyes[2], Richard Cole[1]
[1]*UTMB, Galveston, TX, United States;* [2]*NASA JSC, Houston, TX, United States*

WITHDRAWN

[477] FLIGHT MEDICINE FOR ALL SERVICES - A GUIDE TO ONE OFFS

Michael Yue
U.S. Navy, Patuxent River, MD, United States

(Education - Case Study)

Flight medicine plays a critical role in ensuring the physical fitness and operational readiness of military personnel across various services and nations. The diverse landscape of military services and international collaboration necessitates a wide breadth of understanding of different approaches to flight medicine. This presentation seeks to bridge the gap and provide insights into the unique requirements and considerations when conducting flight physicals and operational medicine for personnel from various military branches and nations. This abstract presents a guide for conducting flight physicals and operational medicine assessments for individuals from different branches of the military, including the US Navy, Army, Air Force, Coast Guard, and Marines. It also explores general guidelines for US military Flight Surgeons when working with patients from other countries. It should also serve as a reference for medical personnel serving in remote locations who will inevitably end up serving aircrew from different services and countries. Through a series of case studies, we highlight the challenges and best practices in providing flight medical services to a diverse military population.

Case Studies:

1. US Navy and US Marine Corps
2. US Army
3. US Air Force
4. US Coast Guard
5. Civilian Aircrew
6. Civilian Passengers
7. Internationals

This guide underscores the significance of tailoring flight medicine to meet the diverse needs of military personnel from various branches and nations. By sharing best practices, and lessons learned through a series of real-life examples, it aims to enhance the effectiveness and efficiency of flight physicals and operational medicine across the military spectrum.

Learning Objectives

1. general familiarity with the different systems used by US military Flight surgeons for aerospace medicine.
2. general familiarity with the different systems used by US Military healthcare providers for readiness tracking.
3. general familiarity with the options for clearing civilians and internationals for flight in US aircraft.

Thursday, 05/09/2024 ***1:30 PM***
Grand Hall K

[S-82]: PANEL: COMMERCIAL SPACEFLIGHT SCOPING REVIEW OF PRIMARY MEDICAL RESOURCES – "CASTOR"

Chair: Tamara Averett-Brauer
Co-Chair: Thomas Hoffman

PANEL OVERVIEW: *As commercial spaceflight (CSF) becomes more available, somewhat more affordable and popular, the greater medical community will be increasingly asked to evaluate the fitness and medical appropriateness of individuals who want to undertake a range of environmental exposures in commercial spaceflights. Currently, the medical screening process is at the discretion of the individual space operators. Notably, there are few publicly available comprehensive standards for screening individuals for short or long-duration flights. This comprehensive and methodologically rigorous CSF Scoping Review (ScR) addresses the emerging topic and research question: What resources or references are available to educate primary healthcare providers about relevant medical considerations to have informed discussions with clients regarding commercial spaceflight travel? Ten teams comprised of international AsMA participants were organized around organ systems to systematically review publicly available literature to identify known, suspected, or potential medical issues and associated risks for CSF and to assess the available literature using Johns Hopkins Levels and Quality of Evidence. Five research databases were queried using the timeframe 2000 to present and using keywords developed by each team. Two panels ("Castor" & "Pollux") will present the findings of the ten teams. The "Castor" panel presents results from five of the ten teams: Neurology/Ophthalmology, Otolaryngology (ENT), Dental, Pulmonary, and Cardiovascular. Each presentation will discuss the methods, results, and discussions related to specific findings of that topical area. The results of this extensive CSF ScR describe the status of the extant literature describing these medical issues and conditions relevant to CSF. Areas of sparse evidence as well as areas for future research are identified. The CSF ScR results provide a resource for primary care medical personnel and build a foundation for recommendations informing future development of medical screening standards.*

[478] DENTAL CONSIDERATIONS IN COMMERCIAL SPACEFLIGHT: A COMPREHENSIVE SCOPING REVIEW

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(Original Research)

INTRODUCTION: Astronauts must go through a strict screening process by a series of NASA based flight physicians, psychologists, technicians, nurses, and dentists prior to being accepted into the astronaut corp. The commercial spaceflight (CSF) industry must seek their own professionals to address their health-related concerns of their crewmembers. Few dentists have been exposed to or studied the concepts of spaceflight related oral health. To assist the dentists and physicians that will be called upon for the CSF industry, our team is conducting an extensive scoping review focusing on dental related conditions relevant to CSF. Our objective is to identify resources for primary dental and medical examiners to adequately inform spaceflight participants regarding relevant dental considerations related to spaceflight. **METHODS:** A rigorous approach was used to identify the publicly available peer-reviewed literature that addresses the human aspects of commercial space flight. The study was initiated with an extended list of dental terminology that was used to conduct a comprehensive systematic literature review across five renowned databases. This process was conducted with the aid of an experienced research librarian, and the databases were limited to peer-reviewed publications from PubMed (Ovid Medline access) CINAHL, EMBASE, PsychINFO, and Web of Science (WOS). **PRELIMINARY RESULTS:** Out of the 5190 studies imported for screening, 1516 duplicates were removed, and 3661 studies were screened, out of those screened 3593 were found to be irrelevant. 68 full-text articles were rigorously analyzed to identify sources relevant to spaceflight dentistry and only a few have explored the realm of spaceflight dentistry. **DISCUSSION**: Our extensive analysis revealed that few studies exist relating to oral health preparations for CSF. During the NASA space program there were some oral-health related issues that occurred (one within two weeks of launch) that could have affected mission success had it occurred during critical moments of a mission. The purpose of our study is to give invaluable insight into the currently available CSF related literature to assist the dental and aerospace community in formulating a set of screening standards, treatment recommendations, and informative discussion with CSF participants.

Learning Objectives

1. Review of the literature related to oral health for Commercial Spaceflight.
2. Create a scientific foundation based on extensive research to aid in the development of provider guidelines for the evaluation and preparation for those wishing to travel into space.

[479] CARDIOVASCULAR DISEASES AND CONDITIONS AND THEIR EFFECTS THAT MAY IMPACT THE COMMERCIAL SPACE FLIGHT PARTICIPANTS: A SCOPING REVIEW

Arthur Formanek[1], Cathy DiBiase[2], Peter Lee[3], Zachery Campbell[4], Wendy Collins[5], Tom Diaz[6], Riley Ferguson[7], Taania Girgla[8], Cyril Mani[9], Gwen Owens[10], Ganeev Singh[11]
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Harvard Medical School, Boston, MA, United States; [11]*University of Massachusetts Chan Medical School, UMass Memorial Medical Center, Worcester, MA, United States*

(Original Research)

INTRODUCTION: We are in a new era of spaceflight where the non-governmental and non-professional citizens can become passengers on suborbital or orbital commercial spaceflight. As cost decreases and number of companies offering these services increases, more people will pursue this opportunity. Spaceflight should be encouraged but a medical screening process to inform and address undue medical risks to the spaceflight participants (SFP) should be considered. Many cardiac and vascular conditions can compromise a potential SFP's ability to perform even simple activities of daily living, which in space, may lead to greater compromise or intensity. Because primary care physicians without aerospace medical expertise may be called upon to determine a SFP's fitness for commercial space travel, we have reviewed the available literature for cardiovascular conditions that may be relevant to this population and report on the current state of the peer-reviewed literature and offer suggestions for future research. **METHODS:** A professional research librarian conducted a search of English language peer-reviewed literature in five databases (PubMed, EMBASE, CINAHL, PSYCINFO, and Web of Science) using a list of search terms developed by consensus within the Cardiovascular Commercial Spaceflight Ad Hoc Committee. Title/abstract screening and full text reviews were facilitated using Covidence software to complete a scoping review. Each article was screened and reviewed for inclusion and exclusion by a minimum of two members of the team with third party arbitration, if needed, by senior team members. **RESULTS:** The final CV list included 99 search terms. The database searches yielded 3293 results. Title and abstract screening were performed before full-text review. The majority of the non-professional astronaut literature focused on analogs (bedrest, centrifuge testing, and parabolic flights). Studies on SFP that have achieved suborbital or orbital flight could not be found in the current peer-reviewed literature. **DISCUSSION:** Cardiovascular conditions searched in this scoping review focused on cardiovascular conditions, and included cardiac masses, dysrhythmias, and congenital disorders. There were many studies that were related to professional astronauts. These included vascular conditions, dyslipidemia, and orthostatic hypotension in returning astronauts. Further research into SFP and their medical conditions and changes in spaceflight need to be explored.

Learning Objectives

1. The participant will be able to identify potential cardiovascular concerns relevant to commercial spaceflight.
2. The participant will understand the implications of existing cardiovascular pathology on the commercial spaceflight participant.

[480] PULMONARY MEDICAL ISSUES AND CONDITIONS RELEVANT TO COMMERCIAL SPACEFLIGHT – A SCOPING REVIEW

Dara Regn[1], Anishka Bandara[2], Nate Barott[3], Lauren Church[4], Phillip Gary[3], Saahil Golia[5], Takuma Ishibashi[6], Christopher Rock[7], Yoshika Saito[8], Matthew William[9], Britt Wiseman[10]

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(Original Research)

INTRODUCTION: With the rapid expansion of the commercial space flight (CSF) market there has been a growing demand for space tourism. To provide information to primary care providers that may perform medical risk assessment of CSF passengers with pulmonary comorbidities, a scoping review (ScR) was conducted to assess available literature regarding pulmonary physiology and to highlight gaps in knowledge and evidence. **METHODS:** A ScR was conducted of peer-reviewed literature published in English from 2000 to present (2023). Search terms were developed by the CSF Pulmonary team using the framework of the Fundamentals of Critical Care causes of respiratory failure and the top respiratory diagnoses in the Global Disease Burden estimates by the World Health Organization. A professional research librarian conducted a search of five databases (PubMed, EMBASE, CINAHL, PSYCINFO, Web of Science). Title/abstract screening and full text review were facilitated using Covidence software. Each article was screened and reviewed for inclusion by a minimum of two members of the team with third party arbitration by senior team members. **RESULTS:** The final pulmonary search term list included (78 number) of terms. The database searches yielded 11,647 results. After the title and abstract screening, full texts were reviewed. The final data set of articles were analyzed, and CSF-relevant pulmonary physiology and comorbidities were identified. There was a paucity of literature specific to CSF participants. What was identified was predominantly level V evidence (reviews, case reports and expert opinion). Literature about professional career astronauts was excluded, however those data are quite informative regarding potential ramifications for CSF passengers. For example, a study looking at microgravity and sleep disordered breathing demonstrated 55% reduction in apnea hypopnea index (AHI) and virtual elimination of snoring. **DISCUSSION:** This methodologically rigorous scoping review provides primary care providers insight into published evidence about pulmonary diseases in CSF. The pulmonary results highlight important considerations for passengers with pulmonary comorbidities and discuss the relevant pulmonary physiology in the context of the known hazards of spaceflight. These results support the aerospace medicine community in informing CSF medical screening standards, outlining a framework for CSF safety regulations, and focusing future CSF research priorities.

Learning Objectives

1. The audience will identify known, suspected, or potential pulmonary medical issues and associated risks with Commercial Spaceflight.
2. The audience will be able to describe one interesting finding in the Scoping Review – a study looking at microgravity and sleep disordered breathing demonstrated 55% reduction in apnea hypopnea index (AHI) and virtual elimination of snoring.

[481] ENT CONSIDERATIONS FOR POTENTIAL COMMERCIAL SPACE FLIGHT PASSENGERS: A SCOPING REVIEW

David B. Wexler[1], Thomas S. Hoffman[2], Heather Panic[3], Brooke Stephanian[4], Sophie Hutton[5], José Pedro Correia[6], Matthew T. Kuntzman[7], Dora Babocs[8], Marian B. Sides[9]

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(Original Research)

INTRODUCTION: The rapidly developing era of commercial spaceflight (CSF) brings a growing interest in spaceflight experiences from potential passengers that lack professional astronaut qualifications. Such individuals across the spectrum of age and health may present initially to primary care providers for medical risk assessment pertinent to CSF. We are conducting an extensive scoping review to assess the available literature on otolaryngological (ear, nose and throat; ENT) medical conditions, with the intent to provide guidance and actionable advice to primary

care physicians. **METHODS:** A professional research librarian conducted a search of English language peer-reviewed literature in five databases (PubMed, EMBASE, CINAHL, PSYCINFO, and Web of Science) using a list of search terms developed by consensus within the CSF ENT working group. Title/abstract screening and full text review were facilitated using Covidence software. Each article was screened and reviewed for inclusion by a minimum of two members of the team with third party arbitration by senior team members. **RESULTS:** The final ENT list included 115 search terms. The database searches yielded 1889 citations. After title/abstract screening, about 15% of the articles were found to be suitable for full-text review. The great majority of the non-professional astronaut literature focused on mechanisms and mitigation of vestibular-related dysfunction, including space motion sickness and spatial disorientation. These articles were often highly technical in nature. There was a distinct paucity of articles pertinent to hearing loss, Eustachian tube dysfunction, sino-nasal disorders in space, and upper aerodigestive tract problems. **DISCUSSION:** This scoping review of ENT conditions pertinent to CSF uncovered a fairly large set of studies on vestibular-related disorders and mechanisms. However, there was highly incomplete coverage of other key ENT management areas, such as pre-existing hearing loss and chronic sino-nasal disorders. The aeromedical/CSF communities should begin exploring how to adapt medical standards and recommendations from traditional sources (e.g., military aviation protocols and the professional astronaut literature) to the medically diverse upcoming populations of CSF spacefarers.

Learning Objectives

1. The audience will understand the methodical search strategy underlying this scoping review (ScR).
2. Participants will recognize that medical research relating to commercial spaceflight (CSF) is an emerging field necessitating the need to adapt current medical standards and recommendations from traditional sources to the medically diverse upcoming populations of CSF.
3. Participants will be able to identify gaps in the Otolaryngological (Ear, Nose and Throat-ENT) literature supporting Commercial Spaceflight, thus suggesting future topics for research.

[482] NEURO-OPHTHALMOLOGY IN COMMERCIAL SPACE FLIGHT: A COMPREHENSIVE SCOPING REVIEW

Lydia Johnson Kolaparambil Varghese[1], Schuyler Link[2], Rachael Filzen[3], Emma Hartness[4], Rafael Tiza Fernandes[5], Tejal Gala[3], Martin G. McCandless[6], Alexander W. Suh[7], Roya Ghafoury[8], Max Tenenbaum[9], Jason-Flor V. Sisante[10]

[1]*Johannes Wesling Klinikum Minden, Ruhr-University Bochum, Minden, Germany;* [2]*Rice University, Houston, TX, United States;* [3]*Keck School of Medicine, University of Southern California, Los Angeles, CA, United States;* [4]*University of Iowa Carver College of Medicine, Iowa City, IA, United States;* [5]*Lisbon School of Medicine, University of Lisbon, Lisbon, Portugal;* [6]*University of Kansas Medical Center, Kansas City, MO, United States;* [7]*Tulane University School of Medicine, New Orleans, LA, United States;* [8]*School of Medicine, Iran University of Medical Sciences, Tehran, Iran;* [9]*University of Oregon Phil and Penny Knight Campus for Accelerating Scientific Impact, Eugene, OR, United States;* [10]*Kansas City University College of Osteopathic Medicine, Kansas City, MO, United States*

(Original Research)

INTRODUCTION: The advent of commercial space flight (CSF) has necessitated the evaluation of medical risks for non-astronauts interested in space travel. Primary care providers play a vital role in evaluating the potential health risks associated with CSF. To assist physicians in this endeavor, we conducted an extensive scoping review focusing on neuro-ophthalmological conditions relevant to CSF. By critically analyzing the available scientific literature, our objective is to provide evidence-based guidance and practical recommendations in assessing and managing neuro-ophthalmological risks in prospective CSF passengers across various demographic profiles. METHODS: A comprehensive systematic literature search was conducted by an experienced research librarian across five renowned databases, namely PubMed, EMBASE, CINAHL, PSYCINFO, and Web of Science. To guide the search, the CSF neuro-ophthalmology working group developed an Excel sheet with search terms organized alphabetically by the etiology of neurological diseases and compartmentally by anatomical considerations for ophthalmological conditions. The Covidence software facilitated efficient screening of titles/abstracts, and thorough evaluation of full-text articles. Inclusion criteria were meticulously assessed by at least two team members, with expert oversight from senior team members to resolve any conflicts. This rigorous process ensures the credibility and integrity of the reviewed literature. **PRELIMINARY RESULTS:** The systematic literature search across five renowned databases yielded 16,369 results, which were then narrowed down to 11,258 articles after removing duplicates. Through title/abstract screening, we further reduced the selection to 653 full-text articles. Rigorous analysis of the included data led to the identification of relevant neuro-ophthalmological pathologies and countermeasures specific to CSF. **DISCUSSION:** Our research furnishes primary care providers invaluable insights into the existing body of published evidence. By shedding light on the physiological facets and coexisting medical conditions relevant to neuro-ophthalmological risks, this study assists the aerospace medicine community in formulating robust medical screening standards for prospective CSF passengers. Furthermore, it establishes a structured framework for the development of safety regulations and serves as a guiding beacon for future research endeavors in the ever-evolving sphere of commercial space flight.

Learning Objectives

1. Review the state-of-the-art literature related to the neurologic and ophthalmological pathology challenges faced during the Commercial Spaceflight era.
2. Based on this scientific background create the basis to develop medical standards and guidelines to apply to individuals that want to access to Space.

Thursday, 05/09/2024 ***1:30 PM***
Grand Hall GH

[S-83]: SLIDES: FATIGUE AND PERFORMANCE

Chair: Ian Mollan
Co-Chair: Merrill Rice

[483] THE DIGITAL PILOT – CONTINUOUS MONITORING OF VITAL SIGNS FOR THE EARLY DETECTION OF HAZARDOUS CONDITIONS

Simon Annaheim[1], Denis Bron[2], Frederik Bauer[1], René M. Rossi[1]

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(Original Research)

INTRODUCTION: The tasks of pilots on duty require high cognitive performance while exposed to the most diverse stressors. To detect conditions that might affect cognitive performance potentially resulting in hazardous situations, we aim to develop a textile-based physiological multi-parameter monitoring tool able to continuously record vital signs, including heart rate (HR) and heart rate variability (HRV), breathing frequency (BF) and breathing variability (BFV) as well as body temperature and heat flux. The goal is to integrate the tool into the pilot suit in a later stage of development. We hypothesize that the system is able to detect changes during exposure to hypoxia. **METHODS:** The monitoring tool consisted of 1) two knitted ECG Electrodes integrated into the textile system, 2) a conductive stretch-sensitive textile sensor to measure respiration by monitoring chest expansion, and 3) a foil heat-flux and temperature sensor. Ten male military pilots (22.4 ± 2.1 years of age) in training were monitored during the occasion of a low-pressure exposition training session

including breathing without oxygen mask at 7500m and 9000m of altitude. Therefore, no ethical approval was needed. Nevertheless, measurements were conducted according to the principles described in the Declaration of Helsinki and written informed consent was obtained from each participant. **RESULTS:** Data was recorded at high quality (95% of ECG data usable for further analysis; 19dB signal-to-noise ratio for respiration data). An immediate drop in HRV was observed (-22%) after removing the mask at high altitude, which was further reduced at the end of hypoxia exposure (-64%). This drop in HRV was accompanied by an increase in HR (+26%). In parallel, an increase in BF and BFV was observed (+21% and 42%, respectively), while the breathing amplitude was reduced (-20%). **DISCUSSION:** We confirmed the feasibility of conducting continuous measurements of vital signs during the training program of military pilots. Furthermore, we were able to detect changes in physiological variables related to hazardous conditions. Additional measurements will be conducted during exposure to other stressors (G forces, training flight sessions) followed by a more in-depth evaluation of the data to detect specific patterns being indicative of psychophysiological conditions of reduced performance.

Learning Objectives

1. Hypoxia exposure immediately affects physiological responses after removing the oxygen mask at an altitude of 7500m potentially affecting psychophysiological conditions and working performance.
2. A continuous monitoring of vital signs on duty bears the potential to early detect changes in psychophysiological conditions and impaired working performance relevant to increase safety in highly demanding situations.

[484] FATIGUE AND ITS ASSOCIATION WITH DEPRESSION AND ANXIETY IN PILOTS OF A MEXICAN CARGO AIRLINE

Alejandro Vieyra-González, Vicente Lozada-Balderrama, Ana Laura Luna-Torres, Armando Rodríguez-López
Instituto Politécnico Nacional, Mexico City, Mexico

(Original Research)

INTRODUCTION: The aviation industry is facing an increasing demand for services; hence, companies attempting to meet this demand seek to make the most of their aircraft by requesting their pilots to work longer hours, rotating, or night shifts. These arduous conditions have been associated with the development of psychopathologies such as fatigue, depression, and anxiety in several studies. The main objective of this research was to evaluate the association of operational fatigue with depression and anxiety in a sample of pilots working for a Mexican carrier. **METHODS:** This investigation consisted of a quantitative, cross-sectional, descriptive, and correlational study on a 54-pilot sample from an airline dedicated to cargo transportation based in Mexico City. An assessment tool that included a informed consent form, a sociodemographic and employment questionnaire, the Sustained Operations Assessment Profile (SOAP) scale to evaluate operational fatigue, the 9-item Patient Health Questionnaire (PHQ-9) to assess depression, and the 7-item Generalized Anxiety Disorder scale (GAD-7) to assess anxiety was applied online. Then, a descriptive and inferential statistical analysis was performed. This study was carried out in accordance with the ethical guidelines applicable in the place of its execution. **RESULTS:** 54 instruments were successfully completed, 96% belonging to male pilots (n=52) and 4% to female pilots (n=2). Fatigue levels were found to have a correlation with the number of hours flown during the last fortnight (r=0.30, p=0.03) as well as with the compliance to the schedule sent to the pilots at the beginning of each month (r=-0.31, p=0.02). The number of hours flown during the last fortnight (r=0.274, p=0.05), as well as the number of overnight layovers during the last fortnight (r=0.33, p=0.02), were correlated to the development of depression. The percentage of compliance to the schedule assigned was inversely associated with the presence of anxiety (r=-0.42, p=<0.01). **DISCUSSION:** Prevalence of depression was 0.36 percentage points higher than the prevalence reported for pilots globally in 2015. Anxiety prevalence was 3 percentage points lower than the last prevalence reported for Mexican population. No previous study with similar criteria in pilots was found to compare the obtained anxiety prevalence. A high and significant correlation of fatigue with depression and anxiety exists among assessed pilots.

Learning Objectives

1. The assistants will be able to identify the working conditions correlated with the presence of fatigue, depression, and anxiety in the sample.
2. The audience will learn about and be aware of the development of other psychopathologies that may be present in fatigued pilots.

[485] PRELIMINARY FATIGUE LEVELS BASED ON PERFORMANCE AND BEHAVIORAL MEASURES

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(Original Research)

INTRODUCTION: As aircraft capabilities advance, operation durations and complexities increase which place higher demands on the pilot which can affect their fatigue, attention, and/or stress levels. These potential risks could be lessened with the help of pilot monitoring solutions. This work aims to investigate and define fatigue levels based on performance and behavioral measures. Previous fatigue studies compared fatigue and no-fatigue conditions. This study investigates how performance and behaviors change as participants get more fatigued. **METHODS:** Participants refrained from sleep, caffeine, tobacco, and alcohol 18 hours prior to data collection to ensure sufficient fatigue. To mimic operational conditions, two lighting conditions were administered. Condition 1 consisted of constant daytime lighting while condition 2 consisted of varied lighting to augment daylight to nightfall transition. Participants performed short flight tasks under each condition until 3 microsleeps occurred. After each task, participants completed the Karolinska Sleepiness Scale (KSS) question, and Psychomotor Vigilance Task (PVT) for response time. Researchers annotated observed behaviors (e.g., blink, eyes closed, yawning, head nod, and fidgeting) during experiments. To assess each participant's fatigue state changes, the data of the first, middle and last intervals of condition 1, and the first and last intervals of condition 2 were used. The PVT and the KSS scores were analyzed using multivariate ANOVA and two-sample t-tests, respectively. **RESULTS:** Between the first and middle intervals of condition 1, there was a significant difference in both the PVT $F(1)=52.3$, $p=6.2e-13$ and KSS scores $t(28.5)=-3.2$, $p=0.002$. Between the middle and last intervals of condition 1, there was a significant difference in PVT $F(1)=5.72$, $p=0.017$. Observed facial behaviors showed similar trend with the PVT scores. **DISCUSSION:** PVT scores provided higher granularity in significantly different scores across data collection compared to KSS as a subjective survey. The significant differences in PVT are used to derive the preliminary fatigue levels as follows: Level 1: <480ms, Level 2: 481ms-680ms, Level 3: 680ms-740ms, and Level 4: >740ms.

Learning Objectives

1. The audience will learn how fatigue self-reports, response times, and behaviors change as humans get more and more fatigued.
2. This study helps derive four preliminary fatigue levels based on performance measures with the support of fatigue behaviors.

[486] MONOCYTE CHEMOATTRACTANT PROTEIN-1 IS INCREASED IN SWISS MILITARY AVIATORS WITH BACK AND NECK PAIN

Kenneth Kincel Jr.[1], Elizabeth Damato[1], Michael Decker[1], Sibylle Grad[2], Andres Kunz[3], Denis Bron[3]
[1]*Case Western Reserve University, Cleveland, OH, United States;* [2]*AO Research Institute, Davos, Switzerland;* [3]*Fliegerärztliches Institut (Aviation Medical Center), Dübendorf, Switzerland*

(Original Research)

INTRODUCTION: Back and neck pain are prevalent among military aviators. Objective biomarkers concurring with the presence of pain, along with accompanying musculoskeletal inflammation are lacking. We sought to determine whether such biomarkers exist. Our heuristic model/hypothesis predicted that proinflammatory serum biomarkers would be elevated in military aviators reporting back or neck pain. **METHODS:** The Swiss Air Force human subjects ethics panel approved this project in which 45 male participants were studied. Each person was categorized according to their frequency of back or neck pain during the prior year. Serum derived from venous blood samples were analyzed for 37 candidate biomarkers using electrochemiluminescent technology. One-way ANOVA was used to determine differences between groups. **RESULTS:** Four groups emerged based on self-reported back and neck pain frequency. Group 1 reported no pain within the past year. Group 2 reported 1-7 days of pain. Group 3 reported 8-30 days of pain. Group 4 reported more than 30 days of pain. Group 1 Monocyte Chemoattractant Protein-1 (MCP-1) levels were 14.68 pg/mL ± 1.63. Significantly higher levels of MCP-1 were found in both Group 2 (17.40 pg/mL ± 1.63, p = .015) and Group 3 (17.58 pg/mL ± 1.91, p = .008). MCP-1 serum levels were also elevated in Group 3 aviators who reported 8-30 days of neck pain (18.44 pg/mL ± 1.93, p = .013) in comparison to Group 1 aviators who reported no neck pain (15.56 pg/mL ± 1.90). **DISCUSSION:** Findings from this prospective cross-sectional study suggest a relationship between presence and severity of self-reported back and neck pain and blood serum levels of the proinflammatory chemokine MCP-1. Confirmation of that relationship will require an experimental paradigm designed to elicit cause and effect. Establishing that neck and back pain are associated with increased blood serum levels of MCP-1 would provide scientific rationale to then determine the cause of that pain. Those findings could support the use of blood serum levels of inflammation as objective markers of neck and back pain/injury as well as to assess efficacy of strategies aimed at reducing such pain and/or injury.

Learning Objectives

1. The participant will understand the prevalence of back and neck pain in Swiss Air Force aviators.
2. The participant will learn that MCP-1 may be an objective biomarker of back and neck pain in military aviators.

[487] THE IMPACT OF CONTROLLED REST ON SELF-REPORTED SLEEPINESS AT TOP-OF-DESCENT

Cassie Hilditch[1], Lucia Arsintescu[1], Sean Pradhan[2], Kevin Gregory[3], Erin Flynn-Evans[3]

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(Original Research)

INTRODUCTION: Long and irregular working hours can lead to fatigue in aviation operations. In some regions, a short nap taken on the flight deck (known as *controlled rest*) can be used as a countermeasure to unexpected in-flight sleepiness. We aimed to investigate the impact of taking controlled rest on self-reported sleepiness at top-of-descent. **METHODS:** Data from 120 long-haul (>6 h flight duration), unaugmented flights were analyzed (n = 31 pilots). Pilots wore actigraphs and completed sleep logs before and during trips. At pre-flight and top-of-descent, pilots completed a Karolinska Sleepiness Scale (KSS). A mixed-effects model was used to assess the impact of controlled rest on KSS at top-of-descent. Sleep duration in the 48 hours prior to departure, timing of the flight (day vs. night), and pre-flight KSS scores were included as covariates. **RESULTS:** Due to missing data, complete data from 83 flights (n = 29 participants) were available in the analyses of the KSS. There were no differences by controlled rest status for KSS scores at top-of-descent (estimated marginal means ± SEM with controlled rest: 5.10 ± 0.22, without controlled rest: 5.37 ± 0.29; p = .45, η^2_p = 0.01). **DISCUSSION:** Our results suggest that there is no difference in self-reported sleepiness at top-of-descent on flights in which controlled rest was taken compared to flights without controlled rest. Further research is necessary to determine the impact of controlled rest on objective measures of performance at top-of-descent.

Learning Objectives

1. Understand how controlled rest may impact self-reported sleepiness at a critical phase of flight.
2. Appreciate the need for further research on controlled rest to understand how the policy is implemented in practice and its impact on objective performance measures.

[488] THE JOINT HELICOPTER COMMAND FATIGUE RESEARCH PROJECT: A CROSS-SECTIONAL STUDY OF FATIGUE IN MILITARY ROTARY WING PILOTS.

Andrew Pelham

Army Air Corps, British Army, Stockbridge, United Kingdom

(Original Research)

BACKGROUND: A study of fatigue in British military rotary wing pilots was undertaken in order to calculate the likely utility of actigraphy-driven fatigue modelling in the military rotary wing environment. **METHODS:** After four UK-based rotary wing squadrons were visited, a total of 48 study participants were recruited across the three services. Objective fatigue was predicted using wearable actigraphy and the Sleep Activity Fatigue Task Effectiveness (SAFTE) fatigue model. Subjective data were collected from daily questionnaires completed by the study participants, including an assessment of their own fatigue, using the Samn-Perelli Scale (SPS). The relationship between these two data sets was then assessed with correlation and linear regression modelling. **RESULTS:** SAFTE scores – the objective measure of fatigue – were shown to decline for night flying, especially if landing >0200hrs (correlation -0.737, $p < 0.001$, R^2 0.55). With increasing subjective levels of fatigue, the relationship between objective SAFTE scores and subjective Samn-Perelli scores in study participants weakened. Pilots had increased levels of objective ($p < 0.05$) and subjective ($p < 0.05$) fatigue when deployed on exercise, compared with non-deployed pilots, and if they lived with children aged under one year ($p < 0.05$) – compared with those with older children. **CONCLUSION:** Actigraphy-driven biomathematical fatigue modelling has a clear role in aspects of military rotary wing aviation. Consideration should be given to its use for night-flying, pilots deployed on exercise and operations, and for those with young children at home. Due to the apparent cognitive burden of rotary wing flying, research into iterative, in-flight objective fatigue measurement in military rotary wing pilots should be strongly considered.

Learning Objectives

1. To understand the likely components of fatigue which military rotary wing pilots are most susceptible to.
2. To understand the circumstances in which bio-mathematical modelling and actigraphy can be used to estimate fatigue in military rotary wing pilots.
3. To understand the likely future avenues for research into fatigue in military rotary wing pilots; this includes, but is not limited to, wearable devices able to offer objective iterative measurement of a pilot's fatigue.

Thursday, 05/09/2024 ***1:30 PM***
Grand Ballroom AB

[S-84]: PANEL: SYSTEM LEVERS WITHIN IMPACT

Sponsored by ExMC

Chair: Jon Steller
Co-Chair: Kris Lehnhardt

PANEL OVERVIEW: *BACKGROUND: Informing Mission Planning via Analysis of Complex Tradespaces (IMPACT) is a computational tool created to assess medical outcome risk for the treated and untreated disease states for*

a growing evidence library that currently includes 119 included conditions. It can also optimize the risk buydown within design reference mission mass and volume constraints and develop requirements for the medical system based on this optimization. Risks are defined by mission parameters (duration, number of crew, # of EVAs, etc.), the incidence of medical conditions, the proportion of pre-defined "best case scenarios" versus "worst case scenarios" definitions, and the three associated outcomes of loss of crew life (LOCL), need for medical evacuation (MED-EVAC), and crew task time affected (TTA). OVERVIEW: The outputs from IMPACT help medical and engineering teams with mission planning, medical system creation, and with crew medical training. A legion of levers is at the disposal of mission planners to help understand mission risk and design solutions. Input levers exist where we may adjust mission parameters or even the mass and volume of the medical system to see how it may affect mission outcomes. Output levers exist as well where mission planners can set thresholds for acceptable LOCL, MED EVAC, or TTA, or even adjust the prioritization of these parameters and see how these affect mission inputs like mass, volume, power, or even medical system resourcing. DISCUSSION: This panel introduces IMPACT, discusses preliminary validation against real world systems, then determines how adjusting levers such as DRM duration, medical system size, or outcome prioritization will affect medical resourcing and mission outcomes for a long-duration Lunar mission.

[489] IMPACT OVERVIEW FOR EXPLORATION SPACEFLIGHT—RISK PREDICTION AND MITIGATION

Arian Anderson[1], Jon G. Steller[2], Ariana M. Nelson[2], Dana Levin[2], Prashan J. Parmar[2], Lynn A. Boley[3], David C. Hilmers[4]
[1]*University of Colorado, Boulder, CO, United States;* [2]*NASA Exploration Medical Capability Element, Houston, TX, United States;* [3]*KBR, Houston, TX, United States;* [4]*Translational Research Institute for Space Health, Houston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: Probabilistic Risk Analysis (PRA) is a method for estimating risk in complex engineering systems. The Informing Mission Planning via Analysis of Complex Tradespaces (IMPACT) tool uses PRA as a customizable predictive analytics tool for quantifying medical risk based on mission profile. IMPACT enables the Exploration Medical Capability (ExMC) element to assess these risks, identify resources necessary to mitigate this risk, and assess the combination of resources that enables the lowest risk within the design constraints of the vehicle. **OVERVIEW**: IMPACT's evidence library (Ev Lib) is a living database that currently contains 119 medical conditions. Each condition is defined with a "best case" (BC) and "worst case" (WC) scenario representing a mild and more severe condition scenario for each medical condition. These scenarios are each associated with outcomes for a treated state (T) and an untreated state (U) yielding a total of 4 possible outcomes for each condition (BC/T, BC/U, WC/T, and WC/U). Each condition's incidence, probability of BC vs. WC, probability of loss of crew life, and the risk of evacuation for each of the four outcome states was determined via literature review. A third metric, task time affected, was obtained via a Delphi style analysis of mission tasks. SMEs then determined the capabilities and resources required to manage each condition within the constraints of exploration class missions. User inputs such as mission duration, medical system size constraints in mass and volume, number of crew, pre-existing conditions, and mission activities allow IMPACT to quantify mission risk, resource allocation, and the achievable risk reduction for a wide variety of potential mission profiles. Quantitative analysis of mission medical risk can then be used by mission planners to optimize and inform medical system design. **DISCUSSION**: This presentation describes the technical aspects of our approach to build the evidence library supporting predictive analytics for medical risks in spaceflight.

Learning Objectives

1. Learn about how IMPACT models system risk for human spaceflight.
2. About how to quantify human health and performance for human spaceflight.

[490] IMPACT REAL WORLD SYSTEM VALIDATION

Prashant Parmar[1], Eric Kerstman[2], Lynn Boley[3], Millennia Young[4], John Arellano[5], Jon G. Steller[1], Dana Levin[1], Ariana M. Nelson[1], Arian Anderson[6], David C. Hilmers[4]
[1]*UTMB—Exploration Medical Capability Element, Galveston, TX, United States;* [2]*UTMB, Galveston, TX, United States;* [3]*KBR, Houston, TX, United States;* [4]*Translational Research Institute for Space Health, Houston, TX, United States;* [5]*Aegis Aerospace, Houston, TX, United States;* [6]*University of Colorado School of Medicine, Aurora, CO, United States*

(Education - Program/Process Review)

BACKGROUND: IMPACT estimates the frequency and consequences of medical conditions that may arise during long-duration exploration missions (LDEMs). A validation analysis of IMPACT was performed with International Space Station (ISS) and Shuttle Transportation System real world system (STS RWS) referent data due to the limited referent data available from exploration missions. **OVERVIEW**: Observed mission and crew characteristics from STS and ISS missions were used as model inputs within MEDPRAT (Medical Extensible Dynamic Probabilistic Risk Assessment Tool). For each mission, 200,000 simulations were generated. Mission model outputs included occurrence counts for each medical condition, total medical events (TME), and the probability of loss of crew life (LOCL). These simulated model outputs were compared to the RWS referent data. The predicted number of total medical events exceeded the total RWS medical events for ISS missions and combined ISS and STS missions. They fell within the 90% confidence interval (CI) for STS missions. For the 32 ISS missions simulated by IMPACT, the number of total medical events was overpredicted for 19 and fell within the 90% CI for 13. For the 21 STS missions, the total number of medical events was overpredicted for 1, in range for 18, and was underpredicted for 2. Combined, 31 missions were in range, 20 were overpredicted, and 2 were underpredicted. LOCL was within the 90% CI. The validation analysis included condition-by-condition analysis. For ISS missions, 49 conditions were in range, 49 were statistically underpowered, 16 were overpredicted, and 5 were underpredicted. Overall, 30% (21/70) of conditions were out of range. For STS missions, results were 40, 59, 10, and 10, respectively. Overall, 30% (20/60) of conditions were out of range. For combined ISS and STS missions, results were 47, 47, 17, and 8, respectively. Overall, 35% (25/72) of conditions were out of range. **DISCUSSION:** The results of this validation analysis are unsurprising given the evidence library driving IMPACT is built for LDEMs and are being validated against short-duration ISS and Shuttle missions. This validation analysis can be used to assess IMPACT outcomes in terms of consistencies and inconsistencies with RWS referent data.

Learning Objectives

1. The audience will learn how IMPACT was validated against real-world system referent data.
2. The audience will learn how variations between predicted and observed conditions can be a function of IMPACT's design and biases.
3. The audience will learn the benefits and limitations of comparison to real-world referent data when there is no current "gold-standard" comparison.

[492] THE EFFECT OF MISSION DURATION ON PREDICTED MEDICAL RISK AND MEDICAL SYSTEM DESIGN CONSIDERATIONS FOR AN EXTENDED DURATION LUNAR MISSION

Dana Levin[1], Prashant Parmar[1], Arian Anderson[2], Jonathan Steller[1], Ariana Nelson[1], Lynn Boley[1], David Hilmers[3]
[1]*UTMB, Galveston, TX, United States;* [2]*University of Colorado, Denver, CO, United States;* [3]*Baylor College of Medicine, Houston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: NASA's Informing Mission Planning through Analysis of Complex Tradespaces (IMPACT) tool suite is designed to predict mission risks from medical events and use combinational optimization techniques to estimate the optimal medical system requirements for

long-duration exploration missions (LDEMs). With a healthy population such as NASA's astronaut corps, a principal driver of medical risk in space is—time. The longer a mission is, the greater the chance of a medical event occurring. This study sought to determine the effect of changing mission duration on mission outcomes and medical system design recommended by the IMPACT tool. **OVERVIEW:** Three IMPACT simulations were run for a design reference mission of 4 crew members with a mission to land on the Lunar surface. The mass and volume constraints were kept the same for all 3 simulations, but the duration was changed from 3 months to 9 months, and to 24 months. The surface duration and number of surface EVAs was also increased corresponding to the increased mission time. Each duration generated different medical system elements with shorter missions carrying lower overall risk and requiring a less complex system when compared to longer missions. Longer durations increased the diversity of medical events that could occur and increased the risk of a medical morbidity affecting clinical outcomes such as loss of crew life (LOCL), need for medical evacuation (MED-EVAC), and of affecting crew task time (TTA). **DISCUSSION:** In each case, the medical system was sufficient to reduce the risks substantially from an untreated baseline illustrating that IMPACT appears to function as designed and likely represents an effective tool for predicting and helping to mitigate medical risk in space for a diverse array of long-duration exploration design reference missions.

Learning Objectives

1. The duration of a mission has substantial effects on health related risks.
2. Predictive analytics tools can help inform medical system design for deep space missions.

[491] THE EFFECT OF MEDICAL SYSTEM SIZE ON PREDICTED MEDICAL RISK AND MEDICAL SYSTEM DESIGN CONSIDERATIONS FOR AN EXTENDED DURATION LUNAR MISSION

Ariana Nelson[1], Jonathan Steller[1], Arian Anderson[1], Dana Levin[1], Prashant Parmar[1], Lynn Boley[2], David Hilmers[7]
[1]*NASA Exploration Medical Capability Element, Houston, TX, United States;* [2]*KBR, Houston, TX, United States;* [7]*Translational Research Institute for Space Health, Houston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: Crew health is impacted by intrinsic human factors, the spaceflight environment, and mission activities. On board medical systems can mitigate mission relevant adverse outcomes such as loss of crew life (LOCL), medical evacuation (MED-EVAC), and crew task time affected (TTA). However, given limited fuel and habitable volume, long-duration exploration missions (LDEMs) require prioritizing the most critical diagnostics and therapeutics. NASA's Informing Mission Planning via Analysis of Complex Tradespaces (IMPACT) tool applies Probabilistic Risk Assessment (PRA) methodology to statistically select the medical capabilities most likely to improve mission success within planner defined mass and volume constraints. This study sought to determine the effect on mission outcomes of changing the mass and volume of the medical system from 20kg/50L, to 50kg/150L, to unlimited. **OVERVIEW:** Three IMPACT simulations were run for a design reference mission of four crew members with a mission to land on the Lunar surface with a 20kg/50L, 50kg/150L, and unlimited size medical system respectively. The size of the medical system significantly affected all mission outcomes (LOCL, MED-EVAC, and TTA) with smaller allocations associated with higher mission risks. **DISCUSSION:** The outputs from IMPACT provide an evidence-based medical system design that can be utilized by SMEs to inform and optimize medical systems for LDEMs and design pre-flight crew training. As the tool is iterative, the database can be updated when new data emerges or with data targeting specific environments (i.e., Lunar vs. Martian) to help continue medical risk mitigation into the future. Here we review the ability of IMPACT to predict the most important clinical resourcing to optimize crew health based on varying vehicular constraints during an extended duration Lunar mission.

Learning Objectives

1. List the key crew health and performance metrics that are used to assess the utility of a given medical system in the IMPACT tool suite.
2. Compare and contrast the relative risk reduction if a larger physical medical system is selected for crewed space missions.

[493] MEDICAL CAPABILITIES THAT INFLUENCE LOSS OF CREW LIFE, MEDICAL EVACUATION, AND TASK TIME AFFECTED FOR AN EXTENDED DURATION LUNAR MISSION

Jon G. Steller[1], Ariana Nelson[1], Dana Levin[1], Prashant J. Parmar[1], Arian Anderson[5], Lynn A. Boley[6], David C. Hilmers[7]
[1]*NASA Exploration Medical Capability Element, Houston, TX, United States;* [5]*University of Colorado, School of Medicine, Aurora, CO, United States;* [6]*KBR, Houston, TX, United States;* [7]*Translational Research Institute for Space Health, Houston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: As we prepare for long-duration exploration missions (LDEMs), mass, volume, and power will limit the resources and capabilities built into the medical system. Thus, the resourcing chosen for the medical system will also be critical for mitigation of loss of crew life (LOCL), medical evacuation (MED-EVAC), and crew task time affected (TTA). Informing Mission Planning via Analysis of Complex Tradespaces (IMPACT) is NASA's newest Probabilistic Risk Assessment (PRA) tool created to assist in selection of the medical capabilities and resources that are most likely to reduce these risks. Furthermore, the tool suite can be used to selectively prioritize reduction of one of these outcomes over the others. We sought to determine how medical system resourcing recommendations may change by independently prioritizing LOCL vs. MED-EVAC vs. TTA. **OVERVIEW**: The levers of IMPACT allow investigators to equally prioritize all three of these mission outcome metrics or to prioritize one outcome over the other. We found that the need for evacuation or LOCL from a medical morbidity is typically driven by rare and serious condition states, whereas the conditions affecting crew task time are often exceedingly more common and benign. Building a medical system with the diagnostics and treatments for conditions leading to TTA is significantly different than a medical system created for decreasing the risk of LOCL and MED-EVAC. **DISCUSSION**: Changing the priority of mission outcomes is just one lever that mission planners may use to buy down medical risk for LDEMs. The outputs from IMPACT help empower SMEs when creating and optimizing medical systems catered to the risk profile desired.

Learning Objectives

1. The audience will learn how prioritizing loss of crew life as a lever within IMPACT can affect suggested medical resourcing and outcomes for a long-duration Lunar mission.
2. The audience will learn how prioritizing the need for medical evacuation as a lever within IMPACT can affect suggested medical resourcing and outcomes for a long-duration Lunar mission.
3. The audience will learn how prioritizing crew task time affected as a lever within IMPACT can affect suggested medical resourcing and outcomes for a long-duration Lunar mission.

Thursday, 05/09/2024 ***3:30 PM***
Grand Ballroom A

[S-85]: PANEL: USING HUMAN BODY MODELING TO PREVENT INJURIES TO AIRCREW

Chair: Micah Kinney
Co-Chair: Lindley Bark

PANEL OVERVIEW: *Since the beginning of human flight, crash protection has evolved to continuously strive for improved survivability and return to duty. With advances in digital human modeling, not only can acute injury be better understood within the context of the aviation environment, but*

chronic injury (e.g., neck, back, and knee pain) prevention can be sought after in developing optimized next generation aircraft. This panel will discuss how the use of finite element digital human modeling is being used at the Naval Air Warfare Center Aircraft Division, in partnership with the Office of Naval Research, academia, and industry, to inform aircrew restraint equipment, seat, and airframe designs. The first topic will highlight how chronic and acute injuries, related to the aviation environment, plague military aircrew readiness and return to flight operations. Second, a discussion on the use of human body modeling to identify head and neck injury causes in mishap recreation. Next, a presentation on how human body modeling can be used to understand injuries to abdominal organs under mishap equivalent forces. Fourth, a brief will be given on lower extremity injury, such as femur and tibia fracture, and how digital modeling is being used to better understand the biodynamics in these crash events. Finally, a wrap up discussion on how digital human modeling supports naval aviation acquisition of improved technology to prevent injury to aircrew.

[494] WHY DO WE NEED MODELING AND WHAT DOES MODELING NEED?

Bethany Shivers[1], Phillip Whitley[2]
[1]*Naval Air Warfare Center Aircraft Division, Patuxent River, MD, United States;* [2]*CFD Research Corporation, Huntsville, AL, United States*

(Education - Tutorial/Review)

INTRODUCTION: Military aircrew neck pain and chronic injury are consistently ranked as a top 10 Aeromedical Issue among all U.S. military branches of service and with our international partner nations. Chronic neck pain and injury diminish operational performance, quality of life, and often lead to early medical retirement. Research methodologies used to investigate causes and mitigation strategies include surveys, post-mortem human subject research, and human volunteer research. Each of these approaches are effective, but also inherently limited in their ability to adequately scope the problem and develop solutions. Modeling provides an avenue to fill in the gap between these research approaches, by taking the results of each approach and connecting the dots. **TOPIC:** While injury prediction models are a critical tool for connecting the dots, they are only as good as the research data available to develop and validate them. Surveys are one of the most common and most easily deployed research tools used to characterize the nature and extent of a problem; however, there are several inherent limitations. As surveys are one of the easiest research tools to use, Warfighters are often inundated with requests to complete them or "participate" in the research. As time is a premium for Aircrew. Like all military occupational specialties, surveys are often either ignored or given little attention or effort. Surveys often lack the specificity needed to capture accurate and meaningful data. A Naval Air Warfare Center Aircraft Division sponsored effort has developed the Operational Neck Pain Index (ONPI), a digital survey that incorporates the core questions identified by the North Atlantic Treaty Organization (NATO) Human Factors Program (HFM) 252 Panel on Aircrew Neck Pain. These questions were developed by panel members to provide the level of specificity necessary to accurately determine the nature and location of pain. **APPLICATION:** The ONPI provides invaluable quality data for modelers looking to characterize the cause or contributing factors to neck pain whether it be focused on longitudinal effects representative of a career's worth of flight exposure, or predicting the effects of various equipment variations or proposed solutions such as helmet and helmet-mounted systems that are under consideration for acquisition efforts.

Learning Objectives

1. The participant will learn about the different research approaches used to investigate the contributing factors and potential mitigation strategies associated with military aircrew neck pain.
2. The participant will learn about the role modeling plays in linking the results from the various research approaches, associated limitations, and data requirements to develop a validated model.

[495] IDENTIFICATION OF INJURIES FOR HEAD AND NECK USING HUMAN BODY MODELS

Nathaniel Owens
Naval Air Warfare Center Aircraft Division, Patuxent River, MD, United States

(Education - Tutorial/Review)

INTRODUCTION: The safety community has put an emphasis on the protecting the head and neck from injury. Because of this, there are currently multiple injury criteria developed for ATD testing. As human body models (HBM) become used more for injury prediction, the application of these injury criteria needs to be adapted or further developed. Many of these criteria were developed with the use of specific accelerometers in mind and not the continuous data available from HBMs. **TOPIC**: Human body models (HBM) are currently being used by NAWCAD Modeling and Simulation (M & S) lab. These HBMs are being used to examine injury potential of the head and neck for many different crashworthy systems that can help protect from high dynamic loading such as seating systems, helmets and harnesses. More time and research is needed to investigate how we can better protect the warfighter from different injury types with the additional information that HBMs provide. **APPLICATION:** NAWCAD is utilizing acute injury human body models from the automotive sector and collaborating with the Office of Naval Research in the development of I-Predict Human model for the fulfillment of Navy's need with a long-term vision of mitigating acute and chronic injuries. The emphasis is on mishap investigations and targeting specific human injuries where effects of posture for chronic injury probability can be evaluated. This information is used for developing guidelines for the warfighters. The applications also include the development/refinement of human tolerance in terms of G force and injury criteria for various anthropometric sizes. NAWCAD is also in the process of collaboration with the medical community to seek interpretation of the results obtained through these models.

Learning Objectives

1. The audience will learn that there are several injury criteria for acute injury in the head and neck.
2. The audience will learn the added capability that human body models provide can be used to better inform crashworthy protective equipment design.

[496] IDENTIFICATION OF VARIOUS TORSO INJURIES USING HUMAN BODY MODELS

Nicholas Harris
Naval Air Warfare Center Aircraft Division, Patuxent River, MD, United States

(Education - Tutorial/Review)

INTRODUCTION: Current methods of predicting human injury from a crash safety prospective rely heavily on anthropomorphic testing devices (ATDs). While these have allowed great advances in crash safety, they are limited to predicting injury at discrete locations in specific conditions. In an attempt to improve injury predicting capabilities, the use of a human body model (HBM) has been implemented. These models have the potential to allow the prediction of a larger variety of injury, lethal and non-lethal, at a larger variety of points on the human body. These HBMs have proved very capable of predicting previously unobservable injuries and give a more complete picture of what happens in a crash. However, the specific criteria that should be used to predict injury is still up for discussion. **TOPIC**: Human body models are currently being used by NAWCAD Modeling and Simulation (M&S) lab to examine injuries that are not being predicted by ATDs. These HBM injury predictions are being used to help influence the design of various crashworthy seating, fall protection, and mobile aircrew restraint systems. The models are evaluating lethal and non-lethal injury to get a more robust and accurate picture of the crash environment. Through this work, it has become clear that identification of injury criteria is needed for several areas of interest. These areas include, but are not limited to, rib cartilage separation, vital organ damage, intestine load, major blood

arteries/vessels loading. **APPLICATION:** NAWCAD is utilizing acute injury human body models from the automotive sector and collaborating with the Office of Naval Research in the development of the Incapacitation Prediction for Readiness in Expeditionary Domains: an Integrated Computational Tool (I-PREDICT) Human model for the fulfillment of Navy's need with a long-term vision of mitigating acute and chronic injuries. The emphasis is on mishap investigations and targeting specific human injuries where effects of posture for chronic injury probability can be evaluated. This information is used for developing guidelines for aircrew protection. The applications also include the development/refinement of human tolerance in terms of G forces and injury criteria for various anthropometric sizes. NAWCAD is also in the process of collaboration with the medical community to seek interpretation of the results obtained through these digital human models.

Learning Objectives

1. The audience will learn about the capability difference between ATD testing and Human Body Model simulation.
2. The audience will learn about the current and future planned uses of human body models for injury prediction.

[497] IDENTIFICATION OF INJURIES FOR LOWER EXTREMITY USING HUMAN BODY MODELS

Aamir Jafri
Naval Air Warfare Center Aircraft Division, Patuxent River, MD, United States

(Original Research)

The aviation safety community has emphasized a need to mitigate lethal injuries pertaining to the head and upper torso. Most aircrew protective systems are designed for protecting the upper extremity, i.e., the head and torso. There is criterion where some discrete location on crash dummies can measure femur load and tibia indexes to record severity of impact, but not much attention is given to those types of injuries in the automotive and commercial aircraft sector. Though these injuries are non-lethal, they have a potential of becoming lethal in the event of a mishap or can disable a warfighter temporarily or permanently which can lead to early retirement. It can also impact the decision-making capability of warfighters during critical task assignments. Hence, there is a need for additional focus on these types of injuries, and how to prevent them, in naval aviation. Human body modeling is currently being used by NAWCAD Modeling and Simulation lab to examine the lower extremity responses for a typical crashworthy seating system that experiences a highly dynamic vertical load during a mishap. Injuries are evaluated accordingly by comparing the model with field data that naval personnel experience during aviation mishap events. The research conducted through these models is not limited to acute harm that is lethal but non-lethal that can be expensive or life-changing. Therefore, more time is devoted to understanding these injuries and the mechanical cause.NAWCAD is utilizing acute injury human body models from the automotive sector and collaborating with the Office of Naval Research in the development of I-Predict Human model for the fulfillment of the U.S. Navy's need with a long-term vision of mitigating acute and chronic injuries. The emphasis is on mishap investigations and targeting specific human injuries where effects of posture or chronic injury probability can be evaluated. Since the acute human models from the automotive sector are developed with necessary details from the perspective of modeling and anthropometry, the effects of occupant preposition on lower extremity injury probability or severity are being evaluated with an aviation context. This information is used for developing guidelines for aircrew protection. NAWCAD is also in the process of collaboration with the medical community to seek additional interpretation of the results obtained through these digital human models.

Learning Objectives

1. Human body models are used to detect injuries that cannot be detected by Crash Dummies. Hence, an accurate understanding of injuries can be researched. Lethal and non-lethal injuries can be evaluated through these models. These models provide a sanity check before finalizing a design.
2. Human body models are being used in the U.S. Navy to develop new injury criteria and refinement of existing injury criteria. The U.S. Navy is using these models to understand aviation mishaps and compare the results of these models with field data.

[498] USING HUMAN BODY MODELS TO SUPPORT ACQUISITION OF INJURY-MITIGATING HARDWARE

Lindley Bark
Missouri University of Science and Technology, Rolla, MO, United States

(Education - Tutorial/Review)

INTRODUCTION: Current employed methods of qualifying crash-protective hardware against crash conditions rely heavily on anthropomorphic testing devices (ATDs). Standardized families of these test devices, when used in controlled testing processes, provide for repeatable and replicable results. As the crash-protective community moves toward future incremental advances in injury mitigation, there is a desire to become more specific with respect to injuries. The majority of these advances will rely on predictive human body models (HBMs). The use of HBMs in the certification/qualification processes is not straightforward. **TOPIC:** In the research environment, HBMs have shown great promise in predicting injuries in ways that previously were not possible. HBMs indicate specific injury mechanisms that are generally not identifiable with physical ATD testing. Further, HBMs are being developed and employed to predict chronic injury in addition to acute injury. The primary issue in bringing HBMs to the acquisition of aviation hardware is the lack of standardization in test methods. One must bring HBM-produced data into the qualification process. Lack of standardization, as exists with ATDs, makes this challenging. However, with aircrew endurance issues, chronic injury issues, and remaining acute injury that is mitigatable, there is strong value in using HBMs. The importance is magnified when we consider that mission durations are significantly increasing. **APPLICATION:** NAWCAD is pursuing HBM analysis to identify means to mitigate injury. Presently, the research in this area is strong and producing promising results. Applying HBMs to the acquisition of hardware will require new means of assessing compliance and even specifying what the compliance criteria may be. Ironically, it may be that the HBMs will provide the vision to get started in developing compliance procedures. This will require collaboration between at least regulatory, medical, engineering, physiology, and acquisition personnel, all focused on achieving reduction in aircrew injury and increasing fleet readiness.

Learning Objectives

1. The participant will gain an understanding of how medical, engineering, and other professionals interact to find elusive solutions to injury mitigation gaps.
2. The audience will gain an understanding of how ATD's and HBMs differ in predicting injury.

Thursday, 05/09/2024 ***3:30 PM***
Grand Ballroom B

[S-86]: PANEL: AEROMEDICAL ETHICS PANEL: SPONSORED BY ASAMS

Chair: David O'Brien
Co-Chair: Karen Heupel

PANEL OVERVIEW: *Aerospace medicine may present an array of potential ethical dilemmas to aviation medicine physicians and other aeromedical professionals that may arise out of conflicts between the interests, rights, and responsibilities of those within our profession, individual patients/aircrew, private employers, and governmental certifying agencies. Case studies will be presented for open audience discussion that address a variety of relevant ethical and/or legal value conflicts in the current practice of aerospace medicine.*

[499] AEROMEDICAL ETHICS PANEL: SPONSORED BY THE AMERICAN SOCIETY OF AEROSPACE MEDICINE SPECIALISTS

Mark Mavity
The American Society of Aerospace Medicine Specialists, McLean, VA, United States

(Education - Case Study)

Aerospace medicine may present an array of potential ethical dilemmas to aviation medicine physicians and other aeromedical professionals that may arise out of conflicts between the interests, rights, and responsibilities of those within our profession, individual patients/aircrew, private employers, and governmental certifying agencies. Case studies will be presented for open audience discussion that address a variety of relevant ethical and/or legal value conflicts in the current practice of aerospace medicine.

Learning Objectives

1. The audience will explore the process of ethical decision-making and its impact upon the practice of aerospace medicine.
2. The audience will learn about the current foundational resources which form the framework of current medical ethical guidance, particularly the ASAMS Ethical Guidelines as they relate specifically to the practice of aerospace medicine.
3. The audience will be encouraged to provide thought and attention to the ethical issues impacting the practice of aerospace medicine.

Thursday, 05/09/2024 ***3:30 PM***
Grand Hall J

[S-87]: PANEL: WHY SHOULD I BE DECLARED UNFIT TO FLY OR TO CONTROL IN 2024?

Sponsored by SOFRAMAS (Francophone Society of Aerospace Medicine)

Chair: Olivier Manen

PANEL OVERVIEW: *Care medicine has been moving all the time, concerning the diagnostic and therapeutic approach, including new medications, protocols, and technologies that are more and more used to improve the prognosis of patients but also their well-being. Medical progress has been taken into account in the official aeromedical regulations such as the EASA rules, that's why a regular updated version of these norms is required, all the more as the philosophy of expertise and of the risk evaluation has changed in time as well, sometimes in a strange way (ARA.MED.330). Accordingly, the aeromedical examiners gradually have been encouraged to push the fitness limits far away. One could summarize by saying that the questioning "Should this pilot or air traffic controller fly or work again?" has moved to "When and in which conditions should he/she fly or work again?" considering particularly one or several operational limitations to be used. In that context, we should question the circumstances that lead to the impossibility to continue the flying/working duties and therefore to a permanent decision of unfitness. If the characteristics of a disease are a key element, many other elements may play an important role such as the status of the aircrew, the specialty and technical role, the working conditions but also the acceptable risk level, the motivation and search for secondary profits… all of them will be discussed through four presentations by military aeromedical experts and one by an occupational practitioner of an airline company.*

[500] WHAT MAKES A FRENCH ATCO UNFIT NOWADAYS?

Sebastien Bisconte[1], Philippe Furtwengler[2], Jonathan Monin[1], Gaetan Guiu[1], Caroline Brescon[1], Mustapha Khezami[1], Laetitia Marion[1], Olivier Manen[1]
[1]*French Health Service, Clamart, France;* [2]*DGAC, Issy les Moulineaux, France*

(Original Research)

INTRODUCTION: Air Traffic Controllers (ATCOs) are subjected to periodical medical examinations during which the aeromedical examiner screens for diseases that could impact the flight safety. The evolution of medical knowledge improves the diagnosis and prognosis of many diseases facilitating the rehabilitation of ATCO. What makes a French ATCO unfit nowadays? The aim of this presentation is to describe the medical causes of ATCOs unfitness by the licensing authority. **METHODS:** All the data from the referral files to the French ATCO licensing authority were collected and analyzed retrospectively. **RESULTS:** From 01/01/2017 to 05/25/2023, 1000 files were analyzed by the licencing authority for 550 different ATCOs [70.3% male, mean age: 44.7 yr +/- 11.2 yr, range 19-70 yr, 12.4% military ATCO] were included. In total, 14.7% of cases resulted in unfitness The first cause is psychiatric with 27 ATCOs declared unfit (33.3%), more than half of them for an anxio-depressive syndrome and a quarter for addictive behaviors. The second reason is ophthalmological with 25 ATCOs declared unfit (30.8%) mainly for dyschromatopsia (33%), stereoscopic vision disorder (18%), keratoconus (11%) or diplopia (11%). Neurology represents the third reason with 11 ATCOs declared unfit (13.6%). Half of them are linked to an epileptic pathology or electroencephalography abnormalities. It should be noted that the cardiology represents only 9 unfit ATCOs (11.1%) mainly linked to coronary artery disease. Finally, oncology represents only 4% of unfitness, mainly for detectable cancers. Pulmonary (sleep apnea), urological (renal colic), ENT or endocrinological (diabetes) pathologies are the cause of almost no unfitness. **DISCUSSION:** This is the first study about this specific population. Psychiatric, ophthalmological, and neurological pathologies are the most likely causes of unfitness among ATCOs. Compared to French aircrew population, there are significantly more causes for ophthalmological unfitness (p=0.005) and fewer causes for neurological unfitness (p=0.02), no significant difference for psychiatric causes. On the contrary, sleep apnea, cancer and urolithiasis most often allow aptitude. This development reflects the evolution of screening techniques and the improvement of medical care.

Learning Objectives

1. Know the reasons for unfitness for air traffic control in France.
2. Highlight the evolution of reasons for unfitness for air traffic control.
3. Discuss the critical medical elements for air traffic control fitness in 2023.

[501] ANALYSIS OF THE PERMANENT INCAPACITY OF AIRCREWMEMBERS OVER THE LAST PAST TEN YEARS (2012-2022), BY THE AIR FRANCE OCCUPATIONAL HEALTH SERVICE

Catherine Cardines, Marie Christine Bouton
Air France, Roissy, France

(Original Research)

In France, civil aircrew members have a double medical follow-up by aeronautical physicians (AME) and by occupational physicians like all French employees. This survey is carried out at Air France's occupational medicine department. The Air France collective agreements specify the terms and conditions of exercise in the event of loss of license (definitive unfitness). Therefore, loss of license must be requested by the aircrew members. The aeromedical expert prepares the file with the various medical elements and then transmits the request to the Civil Aeronautics Medical Council (CMAC). After analyzing the medical file, the CMAC issues the notice of permanent or temporary loss of the medical license. Our study was carried out using computer data identified and entered within the occupational health medical service. This concerns the characterization of the loss of licenses of the Air France air crewmembers, pilots and cabincrews, over the last past ten years: identification according to their function and gender, and the medical causes of the loss of license. We have identified, around 300 loss of license, from 2013 to 2022: Cabincrew (0.42 ‰ to 3.94 ‰) and Pilots (0.27 ‰ to 4 ‰) per year. We will present and discuss about the physical and psychological reasons observed. We

will also discuss the professional future within the company of those who have chosen the option of a retraining offered in the company according to their medico-professional skills, and the support offered for a retraining outside the company.

Learning Objectives

1. This concerns the characterization of the loss of licenses of Air France air crewmembers, technical (pilot) and commercial (cabin crew).
2. Identification according to their function and gender, and the medical causes of the loss of license.

[502] IS A BRAIN LESION ALWAYS DISQUALIFYING IN MILITARY AIRCREWS?

Jonathan Monin[1], Gaëtan Guiu[1], Laëtitia Marion[2], Sébastien Bisconte[1], Caroline Brescon[1], Mustapha Khezami[1], Eric Perrier[1], Olivier Manen[1]

[1]*Aeromedical Center, Percy Military Hospital, Clamart, France;* [2]*Medical Service of Clinical Psychology Applied to Aeronautics, Percy Military Hospital, Clamart, France*

(Original Research)

INTRODUCTION: Brain lesions could be due to numerous causes including head trauma, stroke but also intracranial tumors and infections. They represent a major issue in aviation medicine due to their potential consequences on flight safety such as epileptic seizures or cognitive and motor sequelae. Thus, we decided to perform a study to describe the population of aircrew members with a brain lesion, and to assess the arguments leading to a decision of unfitness in the aeromedical evaluation. **METHODS:** This is a retrospective study including all the military aircrew members with a history of brain lesion, whose medical file had been referred to the military aeromedical commission between 2014 and 2023. Numerous data were collected including flight duty, brain lesion cause, sequelae evaluation, and fitness assessment. **RESULTS:** Among the 1,073 medical files referred to the military aeromedical commission, 41 (3.8%) were of aircrews with brain lesions, mostly males (95%), pilots (51%) with a mean age of 40.2 ± 9.4 yr. 20 airmen (49%) had suffered a stroke, 11 (27%) a head trauma, 8 (20%) a cerebral tumor and 2 (5%) a cerebral infection. An at-risk cortical lesion was found in 66% of cases (n = 27), an EEG was performed for each of them with abnormalities in 6 cases. 24 aircrews (59%) had sequelae: 11 cognitive, 9 motor, 6 ophthalmologic, 4 with seizures. 29 aircrews (71%) were declared unfit, mostly because of an elevated epileptic risk (34%) and cognitive disorders (28%). Being a jet fighter pilot was a risk factor for unfitness ($p = 0.03$) as was the presence of sequelae ($p = 0.01$). **DISCUSSION:** The study reminds us that brain injuries are not such a rare phenomenon in military aircrews. It also underlines the logical link between the presence of sequelae like cognitive disorders or a high epileptic risk with a decision of unfitness. An exhaustive evaluation seems mandatory in this context including MRI, neurocognitive evaluation, and EEG in case of at-risk cortical lesion on the MRI. This evaluation could help aircrews, if no important sequelae is found, to get a waiver.

Learning Objectives

1. To know the main causes of brain lesions in military aircrews.
2. To understand the arguments leading to a decision of unfitness in military aircrews with a brain lesion.

[503] WHICH PSYCHIATRIC CONDITION WILL MAKE YOU UNFIT IN 2024?

Laëtitia Marion, Louis Chevalier, Sébastien Bisconte, Jonathan Monin, Olivier Manen

Aeromedical Center, Percy Military Hospital, Clamart, France

(Original Research)

INTRODUCTION: Military aircrews are a population that has been strictly medically selected. Psychological aspects are assessed from the beginning to the end of their career, due to the exceptional constraints to which they are exposed and to maintain flight safety at its highest level. Despite this assessment, some of them are no longer able to fly due to medical issues. In this study, we focused on the psychiatric causes of unfitness in military aircrews. **METHODS:** This is a retrospective study of the aircrew cases submitted for psychiatric reasons to the military aeromedical commission between January 2017 and September 2023. We were interested in the diagnoses adopted by the aeronautical psychiatrist and the fitness decisions taken by the medical commission: fit, fit with restrictions, temporarily or permanently unfit. **RESULTS:** Among the 759 files submitted to the aeromedical commission between January 2017 and September 2023, 101 (13.4%) were psychiatric files. The average age was 38.8 ± 7.9 yr, 75% were men, and 48% were pilots. The diagnoses were anxiety disorders and depressive disorders for 49% of them, adjustment disorders for 22%, addictive disorders and personality disorders for 17%, PTSD for 12% and psychoses for 4%. 45% were declared fit by the commission, generally with limitations. In terms of diagnosis, psychotic disorders, personality disorders ($p < 0.01$), adjustment disorders ($p = 0.03$) and depression ($p = 0.05$) appear to be risk factors for crew members to be unfit for flight. Flight incidents also correlate with more unfit decisions ($p = 0.02$). **DISCUSSION:** Despite some limitations linked to the retrospective nature of this study, it underlines the high proportion of psychiatric cases among those referred to the aeromedical commission. In addition, this study highlights the differences in terms of fitness prognosis depending on the diagnosis. Except in the case of severe psychiatric disorders, a case-by-case assessment is carried out, taking into account the pilot's experience and background, in order to discuss the possibility of a waiver.

Learning Objectives

1. To highlight the importance of mental health in terms of aeronautical fitness.
2. To better understand the fitness prognosis depending on the psychiatric diagnosis.

[504] BEYOND THE DISEASE, CAN BEING AT RISK MAKE YOU BECOME UNFIT TO FLY?

Nicolas Huiban[1], Mélanie Gehant[1], François-Xavier Brocq[1], Sébastien Bisconte[2], Laetitia Marion[2], Jonathan Monin[2], Catherine Cardines[3], Olivier Manen[2], Marc Monteil[1]

[1]*French Military Health Service, Toulon, France;* [2]*French Military Health Service, Clamart, France;* [3]*Air France, Roissy Aéroport CDG, France*

(Education - Program/Process Review)

BACKGROUND: In his daily practice, the expert may be confronted with a wide range of pathologies, the repercussions of which degrade flight performance. The potentially serious operational consequences can then naturally justify a decision of unfitness. But beyond the simple assessment of the compatibility between a morbid condition, expected performance levels and flight conditions, can a broader reflection on flight safety and the risk of in-flight incapacitation be reasonably concluded by a decision of unfitness? **OVERVIEW:** This question needs to be considered against a backdrop of increasing progress (medical and technological), and a regulatory framework authorizing operational limitations designed to "control" this risk by reducing it to a level deemed "acceptable". But could this approach be relevant in a military environment? In commercial civil aviation, it could make a lot of sense, since the simple addition of a second pilot could statistically reduce the risk of an accident caused by a pilot becoming incapacitated in flight by a factor of 1000. In other words, it would be virtually possible to "eliminate" this risk for air transport operations… But what would happen to a student pilot planning to become an airline pilot, but not yet holding a professional license at the time of the medical examination? Or a Class 2 private pilot? While this approach cannot be directly transposed outside commercial aviation, it appears that the level of safety required is generally lower in private than in commercial aviation. Some authors therefore recommend tolerating a higher risk of incapacitation for private pilots. So, apart from disabling pathologies, could the « simple »

risk legitimately constrain the fitness decision? **DISCUSSION:** In the end, in our current practice, could a decision on unfitness for flight be reasonably motivated by risk factors alone, or by a morbid condition that would be transient or even chronic, but without functional damage or sequelae? We will attempt to develop this question in the light of recent experience at the Toulon AEMC, by using clinical illustrations of military and civilian aircrews, received as part of initial and renewal medical visits.

Learning Objectives

1. To understand strategies for managing the risk of in-flight incapacitation.
2. To know the main causes of unfitness to fly decisions.

Thursday, 05/09/2024 ***3:30 PM***
Grand Hall K

[S-88]: PANEL: MEDICAL EDUCATION IN AEROSPACE MEDICINE: THE ROLE OF CERTIFICATION

Chair: Jennifer Fogarty

PANEL OVERVIEW: *This panel brings together aerospace medicine professionals involved in medical education activities related to the practice of aerospace medicine. Panelists represent different health professions, affiliated specialties, and varying stakeholder views. The first panelist will discuss the role of aerospace certification from the perspective of a Naval O-6 with respect to operational readiness and resource allocation. The second panelist will present the perspective of a civilian aerospace medicine fellowship program that accepts applicants with varied clinical backgrounds including family medicine, internal medicine, and emergency medicine. The third panelist will define aerospace nursing certification and describe a pathway for development. An approach to competency-based medical education models as it relates to aerospace medicine strategies and certification is presented by the fourth panelist. The concluding contribution will detail the viewpoint of a chief medical officer of a private company building a medical team capable of supporting private and government-sponsored astronauts aboard the NASA International Space Station and eventually the first commercial space station.*

[505] AEROSPACE NURSING CERTIFICATION – WHAT IS IT AND WHY DO WE NEED IT?

Cathy DiBiase
NEMCON Aerospace Medicine Group, Cape Canaveral, FL, United States

(Education - Tutorial/Review)

INTRODUCTION: Certification for any profession elevates the individual and the profession as a whole. There are many board certifications in nursing, but none are specific to aerospace nursing. **TOPIC:** Aerospace Nursing is a profession practiced by various groups of nurses both in civilian and military arenas across the world. Nurses practicing nursing within Space Medicine consist of a smaller subset of nurses. A general certification specific to Aerospace Medicine does not currently exist. Though there have been discussions within nursing arenas to promote a certification. other efforts have taken precedence. The urgency of work toward a certification should be promoted and pursued as we enter an era of greater frequency of commercial spaceflight where certification will validate the profession. **APPLICATION:** The goal of this presentation is to present the obstacles toward nursing certification and the education that would accompany this effort.

Learning Objectives

1. The participant will be able to discuss the pertinent benefits of aerospace nursing certification.
2. The participant will be able to describe the obstacles to establishment of a certification.

[506] THE IMPORTANCE OF AEROMEDICAL BOARD CERTIFICATION IN COMMERCIAL SPACE

Michael Harrison[1], Duncan Hughes[2]
[1]*Axiom Space Inc & Hercules Medical Group, Houston, TX, United States;*
[2]*Virgin Galactic, Truth or Consequences, NM, United States*

(Education - Program/Process Review)

BACKGROUND: Board certification in aviation (and later aerospace) medicine was first approved through the American Board of Preventive Medicine (ABPM) in 1953 and has provided specialists to support all manner of flight programs. The aeromedical events and the associated lessons learned from human spaceflight are occasionally high profile but, more frequently and in keeping with the basis in preventive medicine, occur discretely and without widespread awareness. The practice of high-quality preventive medicine has resulted in a stellar track record of mission support wherein primary medical events have very rarely resulted in mission impact. As commercial space opportunities increase and a wider range of health conditions become compatible with spaceflight, the training and certification provided by aerospace medicine training programs accredited by ABPM becomes increasingly important. **OVERVIEW:** No mandate for medical standards currently exists for certifying commercial astronauts for spaceflight. This freedom places significant responsibility on the individual spaceflight providers and their medical departments to practice in the best interest of their crewmembers, mission, company, and overall industry. A solid base as a clinician in a primary specialty and the augmented clinical capabilities provided by accredited training in aerospace medicine is a proven method to produce high quality operational flight surgeons capable of supporting all aeromedical aspects of commercial spaceflight. As commercial operations grow to include more international partners, the pathway to ABPM board certification or recognition of international equivalency becomes less of an obstacle to employment as compared to obtaining US licensure to practice. **DISCUSSION:** As human spaceflight grows to include more commercial operations, the current state of legislation and lack of binding medical standards makes aerospace board certification more important to the safe process of certifying crewmembers for commercial spaceflight and providing guidance on vehicle and mission design/support. It is unreasonable to assume the current training curriculums perfectly meet the needs of the industry but, as has been demonstrated over the past 70 years, the accredited training programs that produce board-certified flight surgeons are capable of adapting to meet the needs of the patient.

Learning Objectives

1. The audience will learn about the practice of aerospace medicine and the value of board certification to commercial space companies.
2. The audience will learn about the history and evolution of accredited aerospace medical training over the past 70 years.

[507] THE IMPORTANCE OF BOARD-CERTIFIED AEROSPACE MEDICINE SPECIALISTS IN THE NAVY

Robert Krause
U.S. Navy, Virginia Beach, VA, United States

(Education - Program/Process Review)

BACKGROUND: The origins of Naval Aerospace Medicine date back to 1912 when the Navy Bureau of Medicine and Surgery issued the first physical standards for Naval Aviation Candidates. Since that time the specialty has grown into a formal residency which was recognized by the American Board of Preventive Medicine (ABPM) in 1953. Aerospace Medicine Specialists have used the foundations of preventive medicine and safety to provide safe aviation and spaceflight operations within the Department of Defense, NASA, the FAA, and other private and government entities. Physical requirements, safety requirements, and cultural competency all play a role in Aerospace medicine and creating the pilot-physician bond which is unique from most other areas of medicine. As aviation and commercial spaceflight expand to a greater population, the training and certification accredited by the ABPM is increasingly important to keep

flying safe. **OVERVIEW:** With increasing demands on military medical providers, the benefit of board certified aerospace medicine specialists has previously been brought into question. The recent experience with COVID often placed an aerospace medicine trained physician at the forefront of prevention and reason for the operational forces that do not have the time to stop their mission. It also highlighted the potential pitfalls that can occur when a provider lacks a preventive medicine background and cannot communicate population health to a community. Additionally, the importance of obtaining cultural competency within Naval Aviation cannot be understated when working with this population. **DISCUSSION:** As the potential for conflict arises with near-peer competitors many medical leaders will be at the tip of the spear working as an advisor and caretaker to the aviators within their purview. Establishing care for this community will be unique and the pilot-physician relationship will be increasingly important. The need for military aerospace medicine physicians may increase as they will need to lead and mentor the less experienced flight surgeons in the practice of preventive medicine which may be foreign to someone with a hospital-centric experience. Understanding safety, risk mitigation, and the clinical aspects unique to the aerospace population cannot be learned overnight and training and working within that environment is critical to obtaining the competencies to succeed within the community and gain pilot trust which ultimately leads to safer missions.

Learning Objectives

1. The participant will understand the importance of cultural competency and the pilot-physician relationship which is unique in Aerospace Medicine.
2. The participant will understand the unique role of aerospace medicine providers within the Navy and why board certification is critical to the Navy's medical mission and success.

[508] CIVILIAN AEROSPACE MEDICINE RESIDENCY: MORE THAN 30 YEARS OF EDUCATING PROVIDERS FROM SHUTTLE TO ISS TO COMMERCIAL SPACE

Serena Auñón-Chancellor
UTMB, Galveston, TX, United States

(Education - Program/Process Review)

INTRODUCTION: With more than 30 years as an established American College of Graduate Medical Education (ACGME) accredited two year Post Graduate Medical Education (PGME) provider in aerospace medicine, this civilian based program has a significant footprint in aerospace medical education. Graduates have supported different eras of spaceflight from Shuttle, to International Space Station, and commercial crew missions. Enriched by a faculty with diverse clinical, physiologic, and disciplinary backgrounds, residents are educated through varied activities. **TOPIC:** A unique asset of the program lies in the four streams: (1) aerospace medicine residency; (2) principles of aviation and space medicine; (3) human health and performance; and (4) aerospace medical school concentration. The aerospace medicine residency program leads medical doctors to board certification. The remaining streams provide an inclusive opportunity, accepting learners at all levels and from different clinical backgrounds. They provide structured formal education, allowing those learners to contribute to other aspects of human space flight. In turn, this may serve to inform and enrich the PGME program. **APPLICATION:** The focus of this discussion will be on the value of aerospace medical education activities targeted at preparing for board certification and those that provided structured exposure without immediately leading to certification. Similar to off service placements in undergraduate medical education (UME) and PGME, there is significant value to accessible aerospace medical education at different levels of learner expertise.

Learning Objectives

1. List three levels of learner that may engage in formalized aerospace medicine education activities.
2. Describe the requirements for board certification in Aerospace Medicine by the American Board of Preventative Medicine (ABPM).
3. Describe the difference between a UME and PGME educational interventions.

[509] COMPETENCY BASED MEDICAL EDUCATION AS A FRAMEWORK FOR THE DEVELOPMENT OF AEROSPACE MEDICINE EXPERTISE

Kathleen Samoil
Simon Fraser University, Burnaby, BC, Canada

(Education - Program/Process Review)

INTRODUCTION: As space mission frequency increases and the number of individuals requiring aerospace medicine expertise to inform and provide clinical care there is value in examining the role of competencies as to inform education and evaluation strategies. These concepts can be carried forward to inform the certification process. **TOPIC:** Competency based medical education (CBME) is the current framework of the Accreditation Council for Graduate Medical Education (ACGME). Milestones, competencies, evaluation, and their relation to clinical outcomes at both the program and individual learner level require a strong framework (Nasca, Philibert, Brigham, & Flynn, 2012). This continues the competency structure for undergraduate medical education outlined by the Association of American Medical Colleges (2023). This work is built of the CanMEDS framework of the Royal College of Physicians and Surgeons of Canada (Frank, Snell, & Sherbino, 2015). This model outlines a model for the development of medical expertise through foundational medical knowledge, clinical skills, and professional values (Frank, Snell, & Sherbino, 2015). A key component of CMBE is the role of external and objective evaluation as it relates to the roles of (1) Communicator, (2) Collaborator, (3) Leader, (4) Health Advocate, (5) Scholar, and (6) Professional. **APPLICATION:** With the move to CMBE for each of undergraduate, post graduate, and continuing medical education activities there are some core tenets that can be used to inform certification of different health professions including medical doctors, registered nurses, physiotherapists, paramedics and beyond within aerospace medicine. These tenets include the role of the external evaluator as opposed to self-assessed expertise. Cross monitoring, and a system of checks and balances as they relate to up to date, ethical, resourceful, and collaborative clinical care.

Learning Objectives

1. Describe two distinct concepts of a competency based medical education framework.
2. List the six unique roles of the medical expert as first described in CanMEDS.

FRIDAY, MAY 10, 2024

Friday, 05/10/2024 ***8:00 AM***
Grand Ballroom ABCD

[S-89]: WORKSHOP: SPACE MISSION ANALOGS: MEDICAL CARE IN REMOTE MARITIME OPERATIONS

Chair: Brian Pinkston

Workshop OVERVIEW: *In the early days of the U.S. Space program, hard lessons were learned through the trials of courageous scientists, engineers, astronauts, and other explorers. One of the most challenging human components of the mission was the safe recovery of astronauts in the hostile environment of the ocean. Pioneers such as NASA flight surgeon, Dr. Bill Carpentier, risked their lives in operational trials to ensure the safety of crew members in maritime operations. Decades of space shuttle missions followed by Soyuz support to the international space station shifted focus from the ocean. However, commercial space operations have returned to the practice of ocean-based recoveries. This has required reinvigoration and retraining in this area as much of the team members with this knowledge have retired. This workshop is intended*