

Such clinical investigations, however, have yet to inform the practices of other nations, namely the USA, where insulin-dependent diabetics are only granted a Class-III medical certificate if approved for receipt of a Special Issuance. **DISCUSSION:** Commercial spaceflight passengers predicted to have several common comorbidities, including insulin-dependent diabetes, utilizing the latest advances in continuous glucose monitoring and insulin delivery will necessarily force industry-driven clinical evaluations of standard-of-care therapies in both microgravity and under hyper-G forces. In minimizing, if not entirely eliminating, certain selection disparities with re-evaluation of current aviation standards, the systematized under-representation of individuals otherwise able to complete all assigned flight tasks with appropriate medical technologies can be undercut to the ultimate benefit of the aerospace industry at-large.

Learning Objectives

1. The audience will learn about regulations and guidelines related to both health and flight status using diabetes as a model for discussion.
2. The audience will learn about potential spaceflight considerations for persons living with well-controlled diabetes including possible metabolic fluctuations given the unique constraints of a microgravity environment.

WEDNESDAY, MAY 20, 2020

Wednesday, 05/20/2020

8:30 AM

Centennial I

[S-47]: PANEL: SPECIFIC ASPECTS OF CIVILIAN AND MILITARY AVIATION MEDICINE IN GERMANY

Sponsored by DGLRM, German Society of Aerospace Medicine

Chair: Jochen Hinkelbein

PANEL OVERVIEW: This session is sponsored by the German Society of Aerospace Medicine (DGLRM). This session is traditionally presented in German language with English slides. Several topics for both civilian and military aviation medicine are presented by five speakers.

[222] CHALLENGING REQUIREMENTS FOR FLIGHT STUDENTS, PILOTS AND ASTRONAUTS – A RADIOLOGIC PROSPECT ABOUT THE NEXT GENERATION MISSIONS

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(Education - Program / Process Review Proposal)

BACKGROUND: Early detection of clinically relevant variations and abnormalities can save lives. To prevent fatal complications in aerospace due to heart attacks or spontaneous intracranial hemorrhage, it is crucial to minimize the risk by regulated screening. **OVERVIEW:** Every year over 340,000 people die from cardiovascular diseases and about 16,000 from spontaneous subarachnoid hemorrhages in Germany. Many result in sudden incapacitation with immediate unconsciousness and the resulting inability to act. Since it can be assumed that the number of unrecognized coronary heart disease, aneurysm carriers in aircrews or unknown malignancies is comparable to the normal collective of the population, it is highly relevant to detect these pathologies in advance. This applies especially to first time applicants for flight duty and to active pilots or astronauts before a long-term space mission, both for safety reasons to avoid disastrous aircraft accidents and from an economic and preventive point of view. **DISCUSSION:** In the German Air Force Center of Aerospace Medicine Department of Radiology, we challenge these in the screening program performed in Fürstfeldbruck. We have to balance between medical assessment, clinical aviation medicine and prevention. With the 3T MRI scanner we can easily produce a high-resolution non-invasive overview of the skull base arteries (Time of flight – MR-Angiography), functional heart diagnostics or screening of the prostate. Preformed aneurysms, malignancies, bleedings or other findings can thus be detected very reliably. However, with new sequence protocols it has been possible to find acoustic neuroma, aneurysm and cavernoma carriers in a cohort of approx. 1500 examinations within the scope of applicant screening

over the last three and a half years. “Going to extremes” is a statement about the new challenging requirements for Human Performance Optimization. Other techniques like low-dose computer tomography are necessary to investigate non-invasive coronary heart disease. We cannot disregard safety reasons in the changed spectrum of clinical assessment. Furthermore, this may also affect manned spaceflight considerably, especially since an increased vulnerability of aneurysms or tumor growing in microgravity cannot be excluded.

Learning Objectives

1. The audience will learn about possible methods for visualizing relevant pathologies at early stages, which may lead to sudden incapacitation.
2. The audience will learn about MRI techniques.

[223] EFFECTS OF ACUTE HYPOBARIC HYPOXIA ON HUMAN PLASMA PROTEOME PROFILE

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(Original Research)

BACKGROUND: Increasing altitude results in Hypobaric Hypoxia (HH) characterized by a decreased oxygenation of the human body. Current data reveals that hypobaric hypoxia during airline travel induces several (patho-) physiological reactions in the human body and protein expression is altered. **OBJECTIVE:** The aim of this narrative review is to provide an overview on cell function responses to acute hypobaric hypoxia. **METHODS:** Retrospective analysis. Recent data was gathered by using the PubMed/MEDLINE® database and the following search string: “hypobaric hypoxia”. Papers were screened by two experienced colleagues independently. **RESULTS:** A total of 2733 studies were identified by the applied search strategy. Data of 20 relevant papers were included. The relevant data demonstrated mild to moderate changes with increase in duration of hypobaric hypoxia exposure. Proteomic analysis showed differential expressed spots, out of which spots were either down regulated or up regulated compared to normoxia control. Bioinformatic analysis revealed an association of the altered proteins especially with the signaling cascades “regulation of hemostasis”, “metabolism, and “leukocyte mediated immune response”. **CONCLUSIONS:** Even though hypobaric hypoxia was short and moderate in many of the studies, analysis of protein expression in human subjects revealed an association to immune response, protein metabolism, and homeostasis. Further investigation is needed to determine protein changes due to hypobaric hypoxia in dependence of the exposed time.

Learning Objectives

1. The audience will learn about the basics of hypobaric hypoxia.
2. The participant will be able to describe the alterations in protein function due to hypobaric hypoxia.
3. The audience will learn about future investigations in hypobaric hypoxia.

[224] GENOMIC REPRESENTATION OF SENSITIVITY TO GRAVITATIONAL FORCES

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(Original Research)

INTRODUCTION: The immune system deteriorates during long-term space flights, probably contributing to an increased susceptibility to infection, autoimmunity, and cancer during exploration class missions. Thus, it is a need to understand the cellular and molecular mechanisms by which altered gravity changes the genomic stability and gene regulation homeostasis and to assess the cellular capacity and mechanisms for adaptation to a new gravitational environment. **METHODS:** In our studies, we investigated signal transduction cascades, adhesion molecules, metabolism, functional parameters, gene expression responses and cytoskeletal dynamics in human lymphocytes and macrophages in different gravity environments through multi-platform approaches (parabolic flights, suborbital ballistic rockets, International Space Station and 2D clinostat and centrifuge experiments), including rigorous control experiments. A multi-platform approach not only allows for cross-validation of findings in independent experiment platforms, but also for understanding the time-course of mechanisms. Our aim was to

investigate the biological cellular phenotype in the force-free conditions of microgravity, potential molecular candidates of the force transduction chain and potential target parameters for mechanistic and functional studies. **RESULTS:** We discovered a rapid adaptation of the oxidative burst reaction in macrophages after 42s, a general high stability of gene expression in altered gravity and rapid initial response after 20s and subsequent adaptation of the transcriptome after 5min altered gravity, which was independent from ion channel function. We identified gravity-regulated genes (e.g. ATP6V1) as well as highly stable reference genes (ABCA5, GAPDH), cross-validated in different platforms and cell types. We found that gene expression changes are not randomly distributed in the chromatin, but clustered in highly stable and responsive loci, which are associated with the geometric position. **DISCUSSION:** The ultra-fast response and adaptation to altered gravity suggests the existence of rapid force transduction processes. Due to the fact, that spatial repositioning of chromosome territories is accompanied by altered transcriptional activity and that chromosome territories are sensitive to mechanical forces, it can be hypothesized that gravity-induced force transduction directly regulates chromatin organization and therefore gene expression.

Learning Objective

1. Understand that gene expression responses to altered gravitational forces are clustered in highly stable and responsive loci in cells of the immune system.

[225] SUPPLY WITH VITAMIN D OF PILOTS AND AVIATION PERSONNEL OF THE GERMAN ARMED FORCES. FIRST RESULTS

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(Original Research)

INTRODUCTION: The main source for vitamin D3 in humans is the own synthesis in the upper layers of the skin with sunlight (80–90 %). Around 10–20 % of vitamin D3 needs are covered by nutrition. 25-OH-VitD is the storage form of the vitamin D3 in the serum. A level, of at least 30 ng/ml is considered sufficient. **METHODS:** In this study, the vitamin D3 values in serum of 2176 subjects (license required-personnel of the Bundeswehr) are evaluated during the investigation period from 01 December 2017 until 30 November 2018. Moreover were considered age, gender, place of employment, body mass index, uric acid, C reactive protein and clinical data (bone diseases, bone fractures) in relation to the vitamin D level of the subjects. **RESULTS:** A total of 71.6 % of all subjects (N = 1557) had a decreased level of vitamin D3, less when 30 ng/ml. Vitamin D3 deficiency (< 20 ng/ml) was found in 25.8 % (N = 648) of the “healthy” subjects. In this study age, gender, body mass index (BMI), uric acid (HSR), C reactive protein (CRP), and place of employment- as well place of residence (postal code regions) in Germany were unrelated to the vitamin D3 deficiency. The known seasonal and monthly variations, depending on the hours of sunshine per month, were confirmed in this study. **CONCLUSION:** When interpreting the data, it should be noted that these are snapshots (point prevalence) of the vitamin D status, as the vitamin was measured only once each during the study per person. With the available data, it is therefore not possible to conclude a long-lasting deficiency. For this reason, in the following studies, the subjects with a low vitamin D deficiency will be further investigated over the course of the year, with further laboratory parameters and clinical symptoms. Because vitamin D is also involved in other metabolic processes, involved in the control of genes and the formation of proteins, this vitamin might have an important role in the prevention of chronic diseases.

Learning Objectives

1. Vitamin D3 values in healthy pilots.
2. Vitamin D3 values depending on the place of residence and the season.
3. Vitamin D3 values depending on gender, age, BMI, C reactive protein and uric acid.

[226] RECOMMENDATIONS ON VACCINATIONS IN INTERNATIONAL TRAVEL

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(Education - Program / Process Review Proposal)

Preparing travel to the global world means careful examination of requirements and regulations of the countries / areas / continents that are planned to be visited. At the same time the immunization status of the travelling individual can be controlled, and vaccinations can be administered to update to basic national recommendations on vaccinations. Now the recommended specific add on vaccinations can be planned, depending on the timeframe starting the journey and the duration of the stay. there will also be a difference in needs regarding backpackers, expatriates or business travelers. The more time is left in advance of the trip the better will be the preparation since there is a need of separation in some life vaccine in contrast to inactivated one. The presentation will also specify the most possible sources where the advising physician will be able to gain accurate knowledge of mandatory or recommended vaccinations e.g. CDC, Ministry of Foreign Affairs and / or special software on travel medicine. Not less important is advice in manners and habits of the various destinations as well as to prepare a first aid kit and how to prevent from other communicable diseases that are not preventable by vaccinations like dengue or malaria.

Learning Objectives

1. The audience will learn that preparing a journey outside the US needs time and planning for vaccinations.
2. The participant will learn where to gain information for a healthy trip stay and safe return.

Wednesday, 05/20/2020

Centennial II

8:30 AM

[S-48]: PANEL: SHORT-HAUL, MULTI-SEGMENT FLIGHT OPERATIONS

Sponsored by Aerospace Human Factors Association

Chair: Tom Nesthus

PANEL OVERVIEW: INTRODUCTION: Many pilots suggest that short-haul flying constitutes some of the highest fatigue risk flying in the industry. Part 117 Table B provides flight duty period (FDP) limitations for un-augmented flight operations. Depending on the time of day an operation begins and the number of segments flown, FDPs range from 9-13 hours. From these operations, to date, there are little data describing the impact on flight-crew sleep, workload, and performance, even though they comprise a significant share of U.S. airlines' daily operations. **TOPIC:** Pilot workload is a significant factor associated with multiple take-offs and landings. Over the course of a long duty day with numerous aircraft changes, short layovers these pairings and sequences often lead to repeated truncated sleep. Regulations provide 10 hrs between FDPs, but time of day or circadian rhythm issues might affect how much quality sleep pilots receive. Unfortunately, again, there are little data quantifying the combined fatigue impact on pilots. Mitigation strategies during short-haul operations are limited due to the nature of the flight operation and the un-augmented crew complement. Also, since there is typically a significant amount of night flying in these operations, rest/napping/sleep opportunities are restricted. U.S. regulations do not allow in-cockpit napping. Public Law 111-216, § 212(B) Fatigue Risk Management Plan (FRMP), provides carriers with a mandate to manage fatigue issues without reporting to the regulator. So, once again, data are sparse or unavailable for identifying best practices and success stories on this topic. **APPLICATION:** This panel session was developed to introduce many of the issues and concerns already expressed, and to discuss some of the regulatory and operational challenges that exist in developing applicable countermeasures and fatigue management strategies.

[227] SHORT-HAUL, MULTI-SEGMENT FLIGHT OPERATIONS: DATA EXAMPLES AND FUTURE DIRECTIONS

Amanda Lamp¹

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(Original Research)

INTRODUCTION: Workload (time on task) is an important factor that influences performance along with time awake and time of day.

While time awake and time of day and their effects on fatigue and performance are easier to quantify, but workload has been more difficult to quantify. Consequently, workload has become a major topic in aviation recently, as scientists and airlines and union representatives try to better understand how this factor effects fatigue and performance in real time scenarios. Current biomathematical models do not include a workload component. In aviation, the primary method to quantify workload is the NASA Task Load Index (TLX), which has a high correlation to performance. Scientists and airline management personnel are working on developing a workload component for the modeling based on TLX data, but this work is preliminary. **METHODS:** The current literature on workload and short-haul operations will be discussed. Data will be presented from our lab comparing short-haul multiple-segment operations and ultra long range (ULR) operations on Safety Performance Indicators (SPIs). We also look at our preliminary TLX workload results on a unique multi-segment flight. **RESULTS:** SPIs for ULR operations are equal to or better than SPIs from short-haul multiple-segment operations. Our TLX workload data demonstrates that, as number of segments increases, workload increases along with fatigue, while cognitive performance degrades. **DISCUSSION:** Quantitative assessment of workload is leading edge research but currently inconclusive. This demonstrates a need to thoroughly assess workload and which flights may be at an increased risk for causing elevated fatigue levels. More data is needed on workload, with the NASA TLX as the primary method of data collection to further understand this fatigue and performance factor. Then, this data needs to be compiled to be used as input into the current biomathematical models.

Learning Objectives

1. The audience will learn about the primary workload method used in aviation.
2. The audience will learn that workload is not easily quantifiable.
3. The audience will learn more data is needed on workload, including as input into the biomathematical models.

[228] SHORT-HAUL, MULTI-SEGMENT FLIGHT OPERATIONS

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(Education - Program / Process Review Proposal)

Since 2014 when the implementation of new flight and duty time regulations were implemented in the U.S., significant resources have been dedicated to fatigue mitigation in long haul operations. Much of this activity has occurred due to the introduction of new, expensive aircraft that have greatly increased capabilities from their predecessors. While much of the flying these aircraft do has the potential for increased fatigue risk, they also provide for increased opportunities for fatigue mitigation. Due to the length of flights, the availability of crew rest facilities and staffing of additional crew members sleep opportunities can be created that very effectively help manage fatigue related risk. One area that has received little attention has been unaugmented short to medium haul flying. These flights are done with minimum numbers of crew and mostly on aircraft without crew rest facilities which makes the opportunity for fatigue mitigation very limited. Many of these flights operate during times of day that limit the opportunity for normal nighttime sleep. Additionally, these shorter flights operate in a very dynamic environment where multiple segments, weather, complex airports, maintenance problems, passenger situations and many other distractions occur. These workload and hassle factors can significantly contribute to the overall fatigue level of crews. Biomathematical fatigue models are widely used in the industry but these tools are limited in many ways. Mostly, they only evaluate the sleep opportunity of crews and do little to nothing to account for the workload and hassle factors experienced by crew members during day-to-day operation. To effectively manage fatigue throughout short-and medium haul operations, these additional factors must be accounted for. This discussion will cover the major workload and hassle factors as well as possible mitigations.

Learning Objectives

1. Understand the limits of fatigue predictions from biomathematical models in aviation.
2. Realize that there are workload factors that add to overall fatigue levels and degraded performance for pilots.
3. Validate the need for continued research dealing with short haul commercial aviation

[229] SHORT-MEDIUM HAUL AIRLINE OPS AND FATIGUE

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(Education - Case Study: Clinical / Human Performance)

Most of the information related to fatigue in airlines is dedicated to long and ultralong haul flights, but the area that really have to be continuously surveilled is the short and medium haul sector, where un-augmented crews regularly fly in 2 to 6 sectors (legs) the same hours and duty time that the long haul augmented crews, without an on board rest facility or rest periods, just a "quick nap procedure" in the cockpit that most of the times is hard to get because of the short cruise time, bad weather, procedures, etc. In a cockpit configuration and seats that are not originally designed to have a pilot flying for 9 hours of flight and up to 15 hours of duty. Another aspect is that these crew schedule is very dynamic, including in the same week early awaking, night flights, evening to early morning flights, etc., with an awaking time than farther than satisfying the sleep and performance physiological needs in a logic mode, obeys to the operational needs and law and contract rest times. Are these pilots performance at the optimum for accurately acting during a critical emergency during their 6th sector (after 5 landings), late afternoon, after an early awake time, with 13 hours of duty and 8 hours of flight already over them? Flight operational quality assurance (FOQA), also known as flight data monitoring (FDM) or flight data analysis, is a method of capturing, analyzing and/or visualizing the data generated by an aircraft, this safety system mainly looks for exceedances on order to point matters that may need to be corrected and to make the crews aware, we have found more FOQA exceedance events after night flights, after several legs, after long duty times and long flying times and after several duties that may compromise the sleep reservoir and performance of the crew, like a long duty 6 sector flight awaking the crew in early morning next day after a night flight. Another aspect to point is that normally the crew roster (flight schedule) is published at the beginning of the month under a fair fatigue surveillance, but on the day to day operations the flight crew schedule may be modified as the crew/ops department needs to comply with operational requirements and to cover unexpected leaves or operations, sometimes letting the crew member to a complete different roster combination that the one that was originally made under a fair fatigue surveillance.

Learning Objectives

1. To introduce the attendee to short-medium haul airline crew duties and fatigue.
2. The attendee will learn about the relation of fatigue and FDM/FOQA events.

[230] A PEER-TO-PEER PROCEDURE TO ASSIST PILOTS ON THE LINE TO DETERMINE IF THEY HAVE ADEQUATE ALERTNESS TO OPERATE THEIR NEXT FLIGHT SEGMENT

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(Education - Program / Process Review Proposal)

Multiple studies have shown that individuals cannot always accurately self-assess their levels of fatigue. Because fatigue affects judgement and self-awareness, individuals may not realize the extent to which alertness and performance has been impaired by the effects of fatigue. In the operational context of an airline this can be problematic, as pilots are expected to self-assess their fitness for duty prior to commencing each flight duty period. Most individuals are better at detecting extreme transient fatigue, but are much less capable of identifying indicators of cumulative fatigue. For short-haul airline operations cumulative fatigue can be a common occurrence, exacerbated by repeated sleep restriction or extended hours of wakefulness across consecutive duty periods. To address the challenge of accurate self-assessment of fatigue levels, one U.S. airline uses a procedure for peer-to-peer conversations between a pilot on the line and a non-flying pilot working in the airline's network operations center. The procedure is used when a pilot calls the operations center to say they are fit to operate their next flight segment (e.g. their third segment of the day) but don't have the necessary level of alertness to operate any subsequent segments (e.g. their fourth segment of the day). The objective of the procedure is to determine if the line pilot actually does have

adequate alertness to continue operating, or if they need to be removed from flying now and be provided with a recovery period. A survey of the airline's pilots found that they were reluctant to make a fatigue callout (and be removed from duty) because they didn't want to inconvenience passengers, fellow crewmembers, or the operation of the airline. Many pilots felt if they could continue operating from an out-station into a domicile there would be more recovery opportunities. In response to these findings, this airline's Fatigue Risk Management Team incorporated this tactical fatigue assessment tool which is used when a pilot requests a prospective fatigue callout.

Learning Objective

1. The audience will learn about a peer-to-peer procedure aimed at assisting pilots to determine fitness for duty prior to commencing a flight duty period.

[231] SHORT-HAUL, MULTI-SEGMENT FLIGHT OPERATIONS: FATIGUE MANAGEMENT REGULATIONS

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(Education - Tutorial Proposal)

Title 14 of the Code of Federal Regulations (14 CFR) part 117, Flightcrew Member Duty and Rest Requirements contains many interactive elements for the management of fatigue. For short-haul, multi-segment flight operations, §117.11, §117.13, and Table B provides flight duty period (FDP) limitations for un-augmented operations. The table outlines pilot duty periods based on the time of day an operation begins and the number of segments flown. The FDPs range from 9-13 hours; with multiple segment flights restricted to fewer hours due to repeated phases of flight with elevated workload conditions. Mitigation strategies during short-haul operations are limited due to the nature of the flight operation and the un-augmented crew complement. There is typically a significant amount of night flying in these operations, so sleep opportunities for many pilots occur during non-optimal times and sleep quality/quantity is affected by circadian rhythms. The regulation section §117.25 describes the rest period requirements and states, the flightcrew member is given a rest period of at least 10 consecutive hours immediately before beginning an FDP. The 10-hour rest period must provide the flightcrew member with a minimum of 8 uninterrupted hours of sleep opportunity. If a pilot experiences excessive fatigue before or during a FDP, regulation section §117.5(c) states that the certificate holder may not permit a flightcrew member to continue an FDP if that flightcrew member has reported him or herself too fatigued to safely continue their assigned duties. Fair and non-punitive company policies must accommodate this potential outcome. Additionally, Public Law 111-216, § 212(B) Fatigue Risk Management Plan (FRMP), provides carriers with a mandate to manage fatigue issues within the limitations of the regulations. If a flight operation or pairing is found to be excessively fatiguing, the certificate holder is responsible for correcting it. U.S. federal documents associated with fatigue management include:

- Advisory Circular (AC) 120-100, Basics of Aviation Fatigue
- AC 117-2, Fatigue Education and Awareness Training Program
- AC 117-3, Fitness for Duty
- Part 117 Preamble text, and Clarification of the Flight, Duty, and Rest Requirements (Docket No. FAA-2012-0358.)

Learning Objective

1. The audience will learn about some of the U.S. regulations associated with fatigue management.

Wednesday, 05/20/2020

8:30 AM

Centennial III

[S-49]: PANEL: DEVELOPING AN EXTREME ENVIRONMENT MEDICAL SYSTEM – LESSONS FROM THE ORION SPACECRAFT

Chair: David Reyes

Co-Chair: Doug Ebert

PANEL OVERVIEW: This panel provides an overview of the development process for the Orion spacecraft medical system with

review of methods, lessons learned, and applicability to the design of medical capabilities for extreme and austere environments. NASA is mandated to return to the moon by 2024, and efforts to build the medical system for Artemis missions using the Orion vehicle are well under way. We will discuss the process of creating a medical kit for the first missions to depart the Earth for the Moon since the days of Apollo. The first panel presentation will provide an overview of the methods used to determine which medical conditions to treat and the resources required. A portion of that work is based on probabilistic risk assessment performed using NASA's Integrated Medical Model, which is the topic of our second report. Due to the short duration of the Artemis missions (< 21 days) and small cabin volume of the Orion vehicle, extremely unlikely medical events were excluded from modelling in order to optimize mass and volume savings. Exclusions and opportunities are detailed in the next presentation, where we discuss trade-offs between NASA requirements, treatment capabilities, and mass/volume constraints. In the fourth report, we discuss the integration of medical capability within the vehicle and the broader mission, using the example of medical water supply. Finally, a contingency scenario is discussed, where we review the medical considerations of a sustained cabin depressurization event. This panel will be useful for those persons planning medical care for extreme environments such as expeditions, far forward deployed military and commercial spaceflights.

[232] TURNING LIMITATIONS INTO OPPORTUNITIES IN THE DEVELOPMENT OF THE ORION MEDICAL KIT

David Reyes¹, Doug Ebert², Christopher Haas¹, James Pavela¹, Josef Schmid³, Derek Nusbaum¹, Christopher Van Velson²

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(Original Research)

INTRODUCTION: Determining what not to treat with the Orion medical system is as important as defining what will be treated. In this work we review the interplay between NASA requirements, constraints, and opportunities for synergy during the development of the Orion medical system. **METHODS:** NASA's required Levels of Care (LOC) for different types of missions (e.g., low earth orbit (LEO) versus lunar) were cross-referenced with medical conditions (primarily drawn from NASA's Exploration Medical Conditions List), and the resources required to address those conditions (baselined to the International Space Station medical capability). Some medical resources were excluded from the Orion system to comply with mass and volume limits, while other resources that could be applied across multiple conditions were prioritized for inclusion. Ideas for integration of multiple medical devices into a single platform were explored. Mission stakeholders (astronauts, flight surgeons, managers) were involved in the process. **RESULTS:** The Orion team identified 50 conditions for exclusion from an initial list of 216, including 17 conditions mitigated by prevention and screening, 15 for which mass and volume constraints limit worst-case treatment capability, 14 for which the vehicle volume limits the probability of trauma, and 4 that are precluded by short mission duration. Remaining conditions with a 'plan to treat' designation were optimally matched with medical resources – for example antibiotics with broad spectrum activity were identified for inclusion, while anticoagulants were de-prioritized given short mission duration and low likelihood of need. Inclusions and exclusions were also examined in light of the LOC standards. A 'hackathon' challenge was entered to generate concepts for combining medical devices into a single app-based tablet (sound level monitoring, ultrasound, electrocardiogram, etc.). **DISCUSSION:** Significant savings in mass and volume are achieved by examining which conditions are improbable, and what resources are necessary versus desired. Opportunities for additional savings and capability in austere environment medical planning are found in screening, prevention, prioritizing capabilities that treat multiple conditions, inclusion of stakeholders in planning, and involving personnel outside the primary development team to bring in fresh ideas.

Learning Objective

1. Learn about opportunities for synergy where limitations might otherwise exist in the development of medical capabilities for extreme austere environments.

[233] USING PROBABILISTIC RISK ASSESSMENT TO INFORM THE DESIGN OF THE ORION MEDICAL KIT

Eric Kerstman¹, John Arellano², Lynn Boley³, David Reyes¹
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(Original Research)

INTRODUCTION: As the National Aeronautics and Space Administration (NASA) plans for human exploration missions, the mass and volume constraints of new vehicles present challenges in design of medical kits. A lunar orbital mission designated as Artemis 2 (A2) is planned for 2022 using the Orion vehicle. The Integrated Medical Model (IMM) is an evidence-based decision support tool using probabilistic risk assessment (PRA) methods that can assess mission risk due to in-flight medical events. The IMM was used to inform the preliminary design of a medical kit for A2 (IMM Service Request S-20180815-406).

METHODS: The IMM generated optimized medical kits for a 21-day A2 mission with four crew. Since the IMM is baselined to the International Space Station, it was modified to better reflect the Orion vehicle. The IMM optimization routine was set to generate two medical kits that maximized crew health, given: 1) a mass constraint of 9.07 kg and no volume constraint, and 2) a mass constraint of 9.07 kg and volume constraint of 13,721 cm³. Primary outputs were a list of medical resources for the optimized medical kits and the probabilities of medical events. Additional outputs included Crew Health Index (CHI, the inverse of quality mission time lost), the probability (0 to 1) of medical Evacuation (pEVAC), probability of medical Loss of Crew Life (pLOCL), and a list of influential medical conditions. **RESULTS:** Over the 21-days the optimized medical kit with only a mass constraint resulted in a mean CHI of 97.20%. The mean pEVAC was 0.0065 and the mean pLOCL was 0.0005. The optimized medical kit with both mass and volume constraints resulted in a mean CHI of 97.20%, mean pEVAC of 0.0074 and mean pLOCL of 0.0005. A list of influential conditions and resources used for both medical kits was also generated. **DISCUSSION:**

The IMM-generated lists of medical resources and probabilities of medical events were used to inform the preliminary design of a medical kit for the A2 mission. Additional subject matter expertise and operational experience was applied to address IMM kit limitations. The next iteration will use the current derived medical kit resource list as IMM input to reassess outcomes. Further refinement of the Orion medical kit may be considered based on these results. This work demonstrates the utility of PRA to provide quantitative estimates of medical risk and resource utilization that may be useful for mission medical planning in other austere environments.

Learning Objective

1. Learn about the use of probabilistic risk assessment as a tool to form a starting place for building medical systems used in extreme austere environments.

[234] A SEMI-QUANTITATIVE APPROACH TO BUILDING THE ORION SPACECRAFT MEDICAL KIT

David Rubin¹, Doug Ebert¹, Christopher Haas², James Pavela², Derek Nusbaum², Josef Schmid³, Christopher Van Velson¹, David Reyes²

¹KBR, Houston, TX, USA; ²University of Texas Medical Branch, Galveston, TX, USA; ³Johnson Space Center, National Aeronautics and Space Administration, Houston, TX, USA

(Original Research)

INTRODUCTION: The Orion spacecraft needs a comprehensive medical system to support its crewmembers during upcoming Artemis moon missions. Identification of this system's components requires an understanding of substantial mission constraints and likely medical conditions. A combination of modeling, subject matter expertise, and historical analysis was used to define the medical system components.

METHODS: Medical conditions from NASA's Exploration Medical Conditions List, augmented by subject matter expertise, were ranked based on 1) metrics that incorporate the probability of that condition occurring during the mission, 2) the complexity of treating the condition, and 3) the futility of attempting to treat the condition. From this ranking, a "plan to treat" condition list was developed and resources for the

diagnosis and treatment of those conditions were identified. A final resource list was determined by including only resources that treated the selected conditions, and met expected vehicle and crew skill constraints.

RESULTS: Of 216 conditions considered ("best case" and "worst case" of 108 unique conditions), 109 "best case" and 52 "worst case" conditions were selected to be included on the "plan to treat" list. Across these 161 condition cases, 479 unique resources were considered for inclusion in the Orion medical system and 168 resources were ultimately selected.

DISCUSSION: The identification of spacecraft medical capabilities and associated resources is a function of 1) potential medical events, 2) the ability of crewmembers to use the selected medical equipment, and 3) mass, volume, and power constraints dictated by the vehicle and mission. Even a well-provisioned medical system does not guarantee that all medical conditions during a mission can be diagnosed and treated; the goal is to minimize medical risk, recognizing that risk cannot be fully eliminated given mission constraints. The methodology used to identify Orion medical system resources provides flight surgeons with an effective framework on which to make informed resource choices, document decisions, and minimize risk. The outcome of this methodology was not simply a resource list, but a record of the step-by-step decision making and justification process. The process developed during this work can be used to design medical systems for future missions and may also be useful for the design of medical kits used in other austere environments.

Learning Objective

1. Learn about a semi-quantitative process for identifying medical resources to build medical kits for extreme environments.

[235] EARLY SYSTEMS INTEGRATION STRENGTHENS ORION MEDICAL CAPABILITIES

Kevin Rosenquist¹, Christopher Van Velson², Christopher Haas³, David Rubin², Doug Ebert², David Reyes³

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(Original Research)

INTRODUCTION: The Orion spacecraft has significant mass and volume constraints, which limit items that can be provided for medical use. Sharing of resources between vehicle systems is therefore required to meet design requirements. This presentation will illustrate resource sharing within the Orion vehicle using medical water drawn from the potable water system as a case study. **METHODS:** Vehicle water is stored aft of the crew compartment in the Orion Service Module tanks and is delivered through the Potable Water Dispenser (PWD). Water for medical purposes must be kept at an appropriate temperature; however, thermal analysis shows that water may be too hot for immediate medical use when initially dispensed. Meeting requirements for water quality, medical use, storage, and disposal during the Orion mission relied on collaboration between multiple vehicle system stakeholders. **RESULTS:** A commercial water bag previously selected to store drinking water was identified as an appropriate method to store water early in the mission and allow it to equilibrate to cabin temperature. This solution resolved the temperature issue but challenged water quality standards. Water quality issues were resolved through identification of potential contaminants and the conclusion that they were benign given the short mission duration. Disposal of the medical water before re-entry was deemed unnecessary because medical contingency water usage would be collected in towels; therefore, a contribution to landing mass would still occur. Materials testing revealed that the water bag is flammable in elevated oxygen environments, but these concerns were resolved by using non-flammable containment (Orion trash bag).

DISCUSSION: A traditional development flow often designs vehicles first, then introduces human systems integration later in the cycle, putting medical systems at a disadvantage. Early connections between crew health stakeholders and other development teams have reduced costs and schedule overruns, while providing the best medical capabilities possible. Logistics planning for austere environment missions should include medical stakeholders from the beginning so that the best medical capability can be provided.

Learning Objective

1. Understand the interplay between different systems and stakeholders to optimize medical capabilities in an austere vehicle environment.

[236] MEDICAL CARE DURING CONTINGENCY SUITED RETURN FOR THE ORION ARTEMIS MISSIONS

Christopher Van Velson¹, Tina Bayuse¹, David Rubin¹, Kevin Rosenquist², Doug Ebert¹, James Pavela³, Derek Nusbaum³, David Reyes³

¹KBR, Houston, TX, USA; ²JES Tech, Houston, TX, USA; ³University of Texas Medical Branch, Galveston, TX, USA

(Original Research)

INTRODUCTION: If the Orion spacecraft were to suffer an unrecoverable cabin depressurization, the capsule would be uninhabitable; the crew would be required to remain wearing pressure suits for up to 6 days (144 hours) for return to Earth. The medical team needs to predict and manage impacts to crew health during this scenario. **METHODS:** NASA flight surgeons determined a list of likely medical conditions during a 144-hour suited return scenario. Conditions were then ranked according to their medical and mission impact. Considering the constraints of the suit, depressurized cabin, and pharmacologic limitations, NASA pharmacists and flight surgeons developed a matrix of potential medications and delivery methods to address these conditions. Options were presented to Orion Program boards, and solutions were determined based on overall mission risk. **RESULTS:** Skin breakdown, infection, anxiety, insomnia, nausea, vomiting, and other conditions were deemed likely in this scenario. To address these and other conditions, medications and their delivery methods (injection, liquids, crushed pills, unaltered pills, compounding, etc.) were assessed for feasibility and effectiveness. Limitations of the suit, the depressurized environment, coupled with drawbacks associated with altering medication and the stability of compounded medications drove the development of a tool to deliver unaltered pills through the existing suit helmet drink port. The physical dimensions of medications appropriate to the treatment of the indicated conditions were measured, and medications were down-selected based on the dimensions of the helmet port. Medications that treat multiple conditions were preferred. **DISCUSSION:** Due to the constraints of medication administration methods at vacuum, pharmacology, and cost of redesigning the suit system, delivering unaltered pills through the existing helmet port was chosen. This method does not allow treatment to a terrestrial standard of care given the extreme austerity of this contingency, but the goal was simultaneous minimization of medical and overall mission risks. Future drug formulations may improve our limited medication options. The process used to determine the components of care in this scenario demonstrate the interplay between medical and mission constraints, engineering, and risk management, and may be useful for persons designing medical capabilities for extreme survival situations in austere environments.

Learning Objective

1. Learn about the methods used to address crew health during an extreme environment contingency situation.

Wednesday, 05/20/2020

8:30 AM

Centennial IV

[S-50]: PANEL: RESIDENT GRAND ROUNDS I

Chair: Edgar Rodriguez

Co-Chair: David Miller

PANEL OVERVIEW: This panel will consist of pairs of Aerospace Medicine residents presenting clinical cases of aeromedical interest or significance. During their residency practicum years, residents conduct evaluations of patients with diverse medical problems. Residents prepare and present a case report based on a patient encounter undertaken during their practicum experience. One resident from each pair presents the history of the presented problem. The other resident presents the physical findings and a discussion of the aeromedical policies associated with the condition. Learning Aerospace Medicine at the specialist level involves understanding the impact of medical conditions on aircrew health and mission accomplishment. The cases presented will not only be of academic interest but will also illustrate aeromedical decision making in the operational environment.

[237] KEEP YOUR EYE ON THE SKY: A CASE REPORT

Christopher Grace¹, Joseph Adams¹

¹U.S. Army School of Aviation Medicine, Fort Rucker, AL, USA

(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: This case report describes a rotary wing aircraft student pilot who experienced vision concerns after surgical repair for a traumatic facial injury. **BACKGROUND:** Accurate vision is essential for the safe piloting of any aircraft. Visual defects that may hinder a pilot's ability to perform all required tasks in the cockpit presents a significant risk to the aircraft and crew. **CASE PRESENTATION:** A 29-year old military flight school student presents with complaints of diplopia five years after surgical repair of a tripod fracture with multiple plating systems and a right lateral tarsorrhaphy. The injury was sustained when a rifle impacted the affected eye during an improvised explosive device (IED) blast during combat operations. **DISCUSSION:** This presentation will cover the extensive treatment and final aeromedical disposition of this complex case. This presentation will highlight the potential dangers of visual deficits in military helicopter pilots. It will also illustrate the benefits of thorough operationally-focused testing to augment the use of standards and medical testing by flight surgeons when evaluating pilots.

Learning Objectives

1. The audience will familiarize themselves with U.S. Army vision standards as applied to the case presentation.
2. The audience will learn about U.S. Army in-cockpit evaluations as applied to aeromedical evaluations.
3. The audience will learn about the impact of facial trauma on vision and corresponding risk to aviation safety as applied to this case presentation.

[238] PECULIAR CASE OF THE AVIATOR WITH A FICKLE FEVER

Karl Swinson¹, Sarah Snyder¹

¹Fort Rucker, AL, USA

(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: This case report describes a fixed wing pilot who presented for follow-up after a short inpatient hospitalization at a civilian hospital for a severe flu-like illness. **BACKGROUND:** This otherwise healthy pilot was discharged after a three-day inpatient stay for a severe flu-like illness. The pilot was asymptomatic at presentation to his unit Flight Surgeon five days after discharge with trending of his hypertransaminasemia. **CASE PRESENTATION:** A 27 year old active duty pilot presents to the aviation medicine clinic for evaluation. He was hospitalized with a fever of 103 degrees Fahrenheit, severe body aches, and chills. Prior to hospitalization, he had returned from a short deployment to Afghanistan where he delivered a fixed wing aircraft and returned to CONUS. He denies any stopovers, layovers, or excursions. He presented to the aviation medicine clinic endorsing good subjective health, but requested to be seen by his unit Flight Surgeon to repeat laboratory testing post hospital discharge for his hypertransaminasemia. The case presentation will include aeromedical disposition and a discussion of Tri-Service/FAA aeromedical regulations related to the case. **DISCUSSION:** Infectious diseases in operational pilots can have serious impacts on safety of flight, as well as the health and welfare of military pilots. Infectious diseases can oftentimes progress to chronic medical conditions if left without proper diagnosis and treatment. Pursuit of waivers and return to duty requires a thorough review of past medical history, stability of the condition, and application of appropriate available waivers.

Learning Objectives

1. The participant will be able to understand the diagnosis and treatment criteria for the presented infectious condition.
2. The participant will be able to determine how to aeromedically disposition a patient with the presented condition.

[239] MY BABY'S GOT THE BENDS...OH NO!

Maxwell Dickey¹, Stephanie Wilson¹

¹U.S. Air Force School of Aerospace Medicine, Dayton, OH, USA

(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: This case report describes a case of neurologic decompression sickness (DCS) in an aerospace physiologist with a history

of migraines. **BACKGROUND:** The possible signs and symptoms of neurologic DCS may include sensory disturbances and alterations of consciousness. Unfortunately, there is also considerable overlap with the aura sensations of classical migraine headaches. Distinguishing etiologies can be difficult in the aviation environment. **CASE PRESENTATION:** Subject is a 26 year-old active duty Air Force aerospace physiologist with a history of lattice degeneration of the retina who at the time of incident had an active waiver for that condition only. During a routine altitude chamber flight the subject experienced bilateral flashes of light during descent as well as blurred vision to the left lateral visual field. Subject remained on 100% O₂ throughout the descent. He was seen by his flight surgeon shortly after the flight, by which point he was nearly asymptomatic and denied any other symptoms. Exam was consistent with report of complete symptom resolution. Subject received hyperbaric O₂ therapy but notably was already asymptomatic prior to therapy and there were no changes. Evaluations by Neurology and USAF Aeromedical Consult Service revealed a 10-year history of migraine headaches with aura and a small patent foramen ovale that was deemed clinically insignificant. **DISCUSSION:** DCS can be a problematic disease process for those with routine exposure to extremes of altitude and the associated pressure changes. Those operating in civilian aircraft and many military airframes generally fly in cabins pressurized to 8,000ft above mean sea level, where the risks of altitude-related illness are minimal. Physiologists with chamber duties, however, often fly up to 25,000ft frequently, at which point risks of hypoxia and DCS are significant. Unfortunately, there is also symptomatic overlap when comparing migraines and neurologic DCS. In this case, light flashes and blurred vision could reasonably represent either etiology and present a diagnostic and treatment conundrum. We can't write off such symptoms as migrainous given the risks of untreated DCS, necessitating hyperbaric therapy anytime they present regardless of the actual cause. As such, there is increased risk of chamber duty disruption with every flight. In light of this, the member was denied a flying class III aeromedical waiver and restricted to non-flying, non-chamber duties.

Learning Objective

1. The clinician will learn to recognize the diagnostic dilemma present in distinguishing the symptoms of migraines from those of neurologic decompression sickness.

[240] STRANGE BEHAVIOR IN AN AVIATOR

Michelle Hong¹, Amy Kreykes¹

¹University of Texas Medical Branch, Galveston, TX, USA

(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: This case report describes a 55-year-old male commercial pilot who presented for a fitness for duty evaluation due to concerns about his flying capability and unusual behavior. **BACKGROUND:** Approximately 7% of American adults struggle with cognitive impairment. Cognitive difficulties place the aviator, passengers and airspace at significant risk for mishap. Brain tumors are one cause of, often subtle, cognitive impairment. Intracranial tumors in adults are due to meningiomas in 36% of cases, making it the most common primary CNS tumor. Meningiomas are typically benign and often discovered incidentally on imaging. Approximately 12% of meningiomas are olfactory. **CASE DESCRIPTION:** A 55-year-old male commercial airline pilot presented at the request of his employer for a fitness for duty evaluation due to concern from peers and management at his company that he had been acting strangely and making mistakes. The patient was late to his appointment and struggled to find the location of the clinic. He has no significant past medical, surgical, or family history and does not use alcohol or illicit substances. He exhibited unusual and labile behavior during the visit. His physical exam was normal. There was concern that he would not be able to safely travel home, and his behavior was sufficiently bizarre to warrant further investigation. A CT head with contrast was obtained same-day and he was admitted to the hospital. **DISCUSSION:** The patient was found to have an olfactory meningioma causing significant changes in executive functioning and behavior due to mass effect and associated vasogenic edema of the frontal lobe. Given the size and symptoms, the best treatment option for this patient is surgical resection. Based on Title 14 CFR Part 61.53, the pilot was grounded, and his company was made aware. The majority of meningiomas have a good prognosis. Following treatment, most pilots can return to unrestricted flying if they remain seizure free. However,

olfactory meningiomas are slow growing and, like this case, patients typically present with a large tumor burden. Because of this, olfactory meningiomas are associated with a higher risk for irreversible visual and cognitive impairment.

Learning Objective

1. Be aware of the signs and symptoms of olfactory meningioma as well as the implications for return to duty.

[241] DOMO ARIGATO DR. BRUGADA

Michael "Cobra" Crowder¹

¹USAF Residency in Aerospace Medicine, Wright Patterson Air Force Base, OH, USA

(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: This case report describes a military flight engineer who was initially diagnosed with Brugada syndrome but it was ultimately determined that the pattern was reversible and related to reversible electrolyte derangement. **BACKGROUND:** Brugada syndrome is an autosomal dominant genetic disorder with variable expression characterized by abnormal findings on the surface electrocardiogram (ECG) in conjunction with an increased risk of ventricular tachyarrhythmias and sudden cardiac death. **CASE PRESENTATION:** The subject aircrew member was a 42-yr old USA Air Force (USAF) K-10 Extender Flight Engineer. He was an experienced flight engineer, with 5323 total flying hours. On a routine ECG he was found to have a spontaneous Brugada-like pattern on ECG and was disqualified from Air Force Flight duties. The flight engineer then pursued multiple and extensive external evaluations suggesting that electrolyte abnormalities may have caused the Brugada-like ECG. After consultation with Dr. Ramon Brugada, it was determined that the pattern seen on the patient's ECG represented normal variants and do not represent true Brugada syndrome. He was ultimately returned to duty after USAF Aeromedical Consultation Service evaluation. **DISCUSSION:** This case highlights the potential issues that arise when aeromedical dispositions are made quickly without thoroughly investigating a given condition, in this case Brugada syndrome. The patient took it upon himself to further investigate his diagnoses, and his efforts were ultimately the key reason that he was able to return to flying status. This case also highlights our duty as a flight surgeon to always be an advocate for our operational patients and "jumping the gun" on dispositions can be deleterious to careers.

Learning Objective

1. Understanding the epidemiology, pathophysiology, adverse outcomes, and aeromedical disposition of Brugada syndrome.

[S-50-A] MITRAL VALVE PROLAPSE IN A C-17 PILOT

S. Alwis¹

¹Sri Lanka Air Force Hospital, Ratmalana, Sri Lanka

(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: This case report describes an active duty military pilot with a history of severe, yet asymptomatic, mitral valve prolapse subsequently corrected with robotic surgical repair. **BACKGROUND:** Abnormalities of the mitral valve annulus, the valve leaflets, the chordae tendinae, or the papillary muscles can cause mitral valve regurgitation. In assessing a patient with mitral regurgitation, it is important to distinguish between degenerative and or functional mitral valve regurgitation. Younger populations tend toward severe myxomatous degeneration, while older populations present with degraded connective tissue leading to chordae tendinae compromise. The most common cause (>50%) of primary mitral valve regurgitation is mitral valve prolapse, but other causes must be considered. Secondary causes usually relate to ischemic and idiopathic myocardial disease leading to a dilated cardiomyopathy. Moderate (or less severe) mitral regurgitation should not cause symptoms. Symptoms of severe mitral regurgitation include reduced exercise tolerance, exertional dyspnea, and orthopnea. Some subjects with severe mitral regurgitation may be asymptomatic with insidious symptom onset unrecognized by the patient. Symptom severity, disease progression, treatment options & follow-up frequency must be considered for occupational risk assessments. Definitive surgical correction may still translate to higher risk if anticoagulant are required. **CASE PRESENTATION:** The subject is a 35 year old male, C-17 pilot training to serve as an air

mobility liaison officer airborne adviser with US Army tactical air control party units. During his medical screening physical a III/VI crescendo-decrescendo murmur was heard at the mitral & tricuspid region. Cardiac evaluation revealed a moderate to severe mitral valve regurgitation presumptively due to a myxomatous mitral valve with anterior prolapse/flail segment. The aircrew member remained asymptomatic with no activity restrictions either before or after surgical repair. He was referred to the USAF Aeromedical Consultation Service for aeromedical risk stratification. **DISCUSSION:** Mitral valve regurgitation is typically classified by echocardiogram as trace, mild, moderate or severe. Trace & mild classifications are usually considered as variations of normal and aeromedically insignificant. Any echocardiogram classification of moderate to severe, regardless of symptoms, indicates further investigation for underlying pathology. Due to the risk of progression, mitral valve prolapse must be investigated, qualified and risk stratified. In the case of mitral valve prolapse, risk of sudden incapacitation and progression to surgical intervention must be carefully considered in context of the mission demands on the affected aircrew and their operational life expectancy.

Learning Objectives

1. Review the aeromedical policies of the US Department of Defense, Federal Aviation Authority, and Sri Lanka government standards for mitral valve regurgitation.
2. Understand the multiple factors associated with aeromedical decision making posed by the presenting condition as well as comorbidities that may or may not be related.

Wednesday, 05/20/2020
Regency 6

8:30 AM

[S-51]: SLIDE: HUMAN SAFETY FROM SEA TO AIR

Chair: Eduard Ricaurte

Co-Chair: Robert Orford

[242] EFFECTS OF AMBIENT LIGHTING ON PERFORMANCE AND LEARNING OF HELICOPTER UNDERWATER ESCAPE SEQUENCES DURING SIMULATION TRAINING

Stefanie Martina¹, Gal Ziv², Elizabeth Sanli³, Heather Carnahan¹
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(Original Research)

INTRODUCTION: There are no universal standards concerning ambient lighting condition during civilian helicopter underwater escape training. This project evaluated the effects of training in the light, dark, or with both conditions on learning and performance of simulated helicopter escape sequences. **METHODS:** Thirty-eight participants were randomized to practice a standardized helicopter escape sequence six times (two times in each of three different seat positions) either in the light, dark, or in the light for three trials and then dark for three trials (graduated). Participants then had a 30 to 60-minute break, followed by retention testing in the dark and then in the light. Dependent measures included accuracy and movement time. All procedures had ethical approval. To assess learning, dependent measures were analyzed with separate ANOVAs with repeated measures on the trial (practice trials conducted in the stroked seat; dark retention test; light retention test) factor. **RESULTS:** For accuracy, a significant main effect of trial was found ($F(2, 58) = 6.012, p = .004, \eta^2 p = .172$). Least Significance Difference (LSD) post hoc revealed that accuracy during the dark retention trial (mean = 4.9 points) was significantly better than during practice trials (mean = 4.4 points; $p = .006$) and the light retention trial (mean = 4.6; $p = .033$). For completion time, a significant main effect of trial was also found ($F(1.839, 53.335) = 5.911, p = .006, \eta^2 p = .169$). LSD post hoc indicated that participants took significantly longer during the practice trial (mean = 44.5 s) than during the light retention trial (mean = 39.2 s; $p = .001$). No other significant effects were found. **DISCUSSION:** Ambient lighting

during training did not appear to impact performance in the light or in the dark. Regardless of training condition, participants performed more accurately during the dark compared to the light retention trial. This could be due to increased arousal elicited by performance in the dark or, alternatively, may suggest that performance of helicopter escape sequences is not visually mediated. Of note, average accuracy across groups for retention tests was five points out of a maximum of seven. Arguably, any score less than seven could have severe consequences in the real-world. Based on findings, it appears that training in the light is suitable for potential performance in the dark. Future research should be conducted with higher fidelity simulations.

Learning Objective

1. The audience will learn about the effects of ambient lighting and role of vision during practice of simulated helicopter underwater escape sequences on learning and performance.

[243] HELP, I'M DIVING, BUT I CAN'T BREATHE! A CASE OF IMMERSION PULMONARY EDEMA PRESENTING AS ACUTE CORONARY SYNDROME?

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¹Philadelphia College of Osteopathic Medicine, Philadelphia, PA, USA; ²NASA Neutral Buoyancy Laboratory, Houston, TX, USA

(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: Immersion pulmonary edema (IPE) is a life-threatening illness seen in both civilian and military swimmers and SCUBA divers. A case will be presented of a SCUBA diver who presented with signs and symptoms of IPE but was incorrectly diagnosed with acute coronary syndrome (ACS). **BACKGROUND:** IPE is being diagnosed more frequently and is even implicated in the death of divers as seen in the literature. It is not taught to physicians or divers; and this knowledge gap can lead to misdiagnosis, subjecting patients to increased risks and healthcare costs. Efforts to close this knowledge gap and improve awareness of IPE are essential to improving outcomes. **CASE PRESENTATION:** A 62-year-old male on day 3 of a diving vacation, dove to 65 feet of salt water (fsw). After 20 minutes, he felt short of breath. Skipping the safety stop, he surfaced, gasping for air. In the ED, the patient was cyanotic when oxygen was removed and had rales bilaterally. Chest x-ray showed lung congestion and initial troponin was negative. The patient, however, was flown to Florida for cardiac catheterization which showed severe 3-vessel chronic coronary artery disease with extensive collaterals. He was taken to the OR for a 5-vessel coronary artery bypass graft (CABG). On post-operative day 3 he developed atrial fibrillation, was chemically cardioverted, and discharged on an antiarrhythmic and blood thinner. Total cost of care was \$494,000. **DISCUSSION:** IPE can have a classic history and physical when physicians ask the right questions. Even when it does, it is often misdiagnosed due to inadequate knowledge in the medical community. While ACS is a more debilitating process than IPE overall, misdiagnosis can be very costly and subject patients to risky therapies. Even when the respiratory aspects were noted, this patient was still tracked into a coronary pathway, air lifted to the U.S., underwent catheterization, and completed a six-month rehabilitation routine. Since this occurs in both civilian and military swimmers and divers, it is important for clinicians to be trained in the diagnosis and management of IPE.

Learning Objectives

1. The audience will be able to recognize the signs and symptoms of IPE, as well as appropriate treatment of IPE.
2. The audience will learn about SCUBA diving related illnesses and what questions to ask patients for evaluation.

[244] EMERGENCY AEROMEDICINE: UPDATE ON MASS CASUALTY CENTER PROJECT FOR SURGERY AND DISASTER RESPONSE WORLDWIDE

Russell Andrews¹

¹World Federation of Neurosurgical Societies & NASA Ames Research Center, Los Gatos, CA, USA

(Original Research)

INTRODUCTION: One-third of deaths worldwide result from lack of surgery (10 times those dying from AIDS, TB, or malaria) with an annual GDP loss > US\$500B in low- and middle-income countries (LMICs). Many

of the 100,000s of deaths annually from disasters - both natural and "un-natural" (man-made), e.g., infrastructure failure and terrorism - result from delayed mass casualty response (MCR). In many LMICs, lack of resilient healthcare infrastructure (e.g., frequent power outages) contributes to unnecessary morbidity/mortality (M/M). **METHODS:** Trauma/Stroke Centers (T/SCs) evolved with evidence that immediate treatment improves M/M. Mass Casualty Centers (MCCs), seamlessly integrated like T/SCs, include battery-powered CT scans, helicopter-portable operating rooms, telemedicine/telesurgery, and robots/drones to optimize triage and identify living buried in rubble. The MCC Project integrates civilian, military, and international/NGO resources to increase efficiency and decrease duplication of healthcare resources. The two initial MCC sites are in Chile and Pakistan. **RESULTS:** Personnel involved in the MCC Project to date include physicians, nurses, international trauma and telemedicine/telesurgery experts, digital healthcare developers, international medical education experts, former ministers of health from three LMICs, and a former CEO of the National Health Service (UK). In Chile, meetings have been held with local healthcare officials as well as the Ministry of Health and Office of Emergency Response (ONEMI), medical leaders from the Air Force and the Navy (and soon with the Army) - with positive response regarding a Chilean MCC. In Pakistan (Peshawar), two hospitals have been built, medical and nursing schools opened, and ambulance service established. Meetings have been held with the regional Military Corps Commander, with a further meeting scheduled for November, 2019, regarding integration of military and civilian healthcare resources. **DISCUSSION:** The MCC Project improves both daily healthcare in the region served and MCR, and establishes both global medical education standards and research platforms. MCCs provide resources (e.g., radiology, blood bank, pathology) necessary for *Lancet Global Surgery 2030* and WHO 2030 Sustainable Development Goals (for healthcare, education, poverty). There are political and socioeconomic benefits - beyond immediate healthcare benefits - of MCCs integrating MCR and resilient surgery into ongoing global healthcare.

Learning Objectives

1. The participant will learn about the healthcare impact of mass casualty disasters (both natural and man-made), the limitations of current mass casualty disaster response systems, as well as the healthcare impact of lack of surgery worldwide.
2. The participant will learn about the aeromedical and other resources available for immediate medical/surgical care in both mass casualty disasters and daily healthcare delivery.
3. The participant will learn about the benefits - both for mass casualty disaster response and for global healthcare - of using the trauma/stroke center model for integrating mass casualty disaster response into ongoing healthcare systems.

[245] U.S. AIR FORCE COMBINED MISHAP REDUCTION SYSTEM (AFCMRS) AND U.S. AIR FORCE SAFETY AUTOMATED SYSTEM (AFSAS)

Heather Tevebaugh¹, Geoffrey Ewing¹, Michael Luby¹
¹Air Force Safety Center, Kirtland AFB, NM, USA

(Education - Program / Process Review Proposal)

BACKGROUND: Previous mishap analysis and research positively correlates resources, processes, culture and leadership to organizational effectiveness and safety culture. A tool to effectively measure and communicate safety culture to line commanders is useful for proactive safety programs. Further, each military safety center employs a safety system to report, track, and data mine mishap investigations. Combining information from safety culture surveys and prior mishap investigations can benefit commanders and safety personnel. **OVERVIEW:** The U.S. Air Force Safety Center employs the Air Force Combined Mishap Reduction System (AFCMRS) to provide commanders proactive actionable resource, process, culture and leadership analysis to positively influence organizational effectiveness and safety. Further, the Air Force Safety Automated System (AFSAS) is the web based system for all mishap related investigations. **DISCUSSION:** This presentation outlines the AFCMRS and AFSAS structure, program execution, input requirements, product output, and its role in unit organizational culture and investigative process. Further, attendees will be shown how both systems benefit operational effectiveness and safety culture. Additionally, this presentation provides foundation knowledge for the remaining presentations in this panel.

Learning Objective

1. The audience will understand how AFCMRS addresses the critical importance of organizational effectiveness and safety and the capabilities of AFSAS.

[246] A CLOSE SHAVE: THE RISKS OF FACIAL HAIR IN THE AVIATION SETTING

Gwynne Harper¹

¹RAF Centre of Aviation Medicine, Henlow, United Kingdom

(Education - Program / Process Review Proposal)

BACKGROUND: In September 2019 the UK Royal Air Force (RAF) changed uniform regulations to permit growth of a full set beard by Serving personnel for the first time. A general reservation was retained for occupational, operational or safety reasons which resulted in the need to consider facial hair in the context of flight safety for the first time in RAF aviation. **OVERVIEW:** There is limited evidence on the safety of aircrew flying with beards, and UK qualification testing for fast jet oxygen systems has only been carried out using clean-shaven subjects. A literature review found only 4 articles directly related to facial hair in aircrew. Including evidence from relevant non-aviation close-fitting mask systems, identified a total of 10 articles, 3 industry standards and 1 news article. These documented several hazards of aviation significance, the most significant of which were inboard and outboard leak, loose hairs, mask loss and flame propagation. In turn, these have potential to result in hypoxia, exposure to noxious substances, decompression sickness, valve compromise and burn injuries. It was found that the majority position of international military and civil policy and regulation was therefore to limit or ban beard growth by aircrew. **DISCUSSION:** The implications for risk to life are clear, for both military and civilian populations. However, the risk differs between those who routinely wear a mask in-flight and those who may only require a mask as an emergency action. The limited available evidence means that quantifying the overall risk from the identified hazards is impossible; however, no practical future test or trial regime could provide equivalent assurance to that available for clean-shaven personnel. Overall, the available evidence therefore suggests that facial hair that compromises mask seal may constitute an unacceptable risk for aviators who routinely wear a mask, and should be carefully risk-assessed for those who may have to rapidly or unexpectedly don mask-based personal protective equipment.

Learning Objective

1. The audience will benefit from a review of the current evidence on the potential hazards of facial hair in the aviation setting.
2. The audience will be able to reflect on their own organization's policies with regard to facial hair, benchmarked against evidence and the consensus position.

[247] THE EFFICACY OF OXYGEN DELIVERY MASKS FOR COMMERCIAL PILOTS WITH FACIAL HAIR

Sherri Ferguson¹, Dan Warkander¹, Evan Hutcheon¹, Sam Doesburg¹
¹Simon Fraser University, Burnaby, British Columbia, Canada

(Original Research)

INTRODUCTION: The current policies in Canada for commercial pilots to be cleanly shaven is based on outdated research done in the 1970s. Some countries allow commercial pilots to operate commercial aircraft with a beard; however, no research has been done on current equipment and its efficacy with a bearded user. This study looked at the efficacy of two masks currently in use on commercial aircraft with bearded users. **METHODS:** We measured participants (n=30) of different beard lengths (i.e. <0.5cm, 0.5-12.5cm, and >12.5cm). We then tested the masks at 4 altitudes (i.e. 10,000 ft, 17,000 ft, 20,000 ft, 25,000 ft) and whether they protected against noxious gas exposure (i.e. stannic chloride) while in "Emergency" mode of operation. **RESULTS:** We found that all participants were unable to detect the noxious gas while wearing a mask and that none of the participant's blood oxygen saturation levels dropped below 93%. Reassuringly, 27 participants had the lowest blood oxygen saturation level of 98% or greater, one participant's lowest blood oxygenation level was 97%, and another participant had the lowest blood oxygen level of 93%. **DISCUSSION:**

The results of this study suggest that the current masks maintain efficacy for hypoxia prevention and ensure no inward air or fumes into the mask when used at altitudes up to 25,000' even with a bearded user. Further testing should be done to determine the additional gas requirements if any when used in emergency mode to ensure sufficient autonomy in the worst-case scenario. Also testing should be done to determine adequate pressure can be achieved to protect against hypoxia at altitudes above 36,000' ASL

Learning Objective

1. The audience will learn about how testing has been performed on oxygen delivery masks for pilots and the results to help guide their decision-making process for their application.

Wednesday, 05/20/2020
Regency 8

8:30 AM

[S-52]: PANEL: COGNITIVE PERFORMANCE TESTING FOR THE AEROSPACE ENVIRONMENT

Chair: Ryan Mayes

Co-Chair: Richard Arnold

PANEL OVERVIEW: The aerospace environment poses multiple challenges to pilots and other operators; one of the most important challenges is high cognitive demand. Consequently, tests that accurately capture cognitive performance relevant to the aerospace environment are necessary for use in selection and classification, medical screening, training, and research. This panel will present several different tests used by various U.S. federal aeromedical labs and aviation support functions; for each test, development, validity, and implementation will be discussed. The Naval Air Warfare Center Aircraft Division will present SYNWIN, which is used in aviation research. NASA will present the Multi-Attribute Task Battery (MATB). The Navy Medical Center Portsmouth will present the Cog Screen tool used in aeromedical evaluation. The US Air Force School of Aerospace Medicine (USAFSAM) and the Institute for Human and Machine Cognition will present a newly-developed cognitive test designed to aid in sensor development, followed by a comparison of the novel assessment to existing tools. Finally, the panel will lead a discussion comparing the various cognitive tests.

[248] CRITERION VALIDITY OF THE AIR FORCE PERFORMANCE ASSESSMENT TOOL

Jeffrey Phillips¹, **Ryan Mayes²**, **Brittany Neilson¹**, **Sabrina Drollingner³**, **Steven Linnville⁴**, **Michelle Sciarini¹**
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(Original Research)

BACKGROUND: The purpose of the current study was two-fold: 1) to determine the Performance Assessment Tool (PAT)'s sensitivity to the performance effects of hypoxia exposure at two levels of workload (high and low) and 2) to establish criterion validity by comparing the PAT at two levels of workload to hypoxia effects measured by the CogScreen Visual Sequence Comparison (VSC), which has been previously established as being sensitive to hypoxia. **METHODS:** Twenty-five student Naval Aviators at Naval Air Station Pensacola, FL participated in the study. All were men with ages ranging from 22 to 29 years ($M = 23.48$ years, $SD = 1.56$ years). Participants performed three cognitive tasks (PAT low workload/tracking only, PAT high workload/multitasking, and CogScreen VSC) across three trials during a normoxia session first and then again for three trials during the hypoxia session that followed. **RESULTS:** Three 2 (normoxia vs. hypoxia) x 3 (trial) Factorial Repeated-Measures Analysis of Variance were computed for performance on each task (PAT low workload/tracking only, PAT high workload/multitasking, and CogScreen VSC). The analysis of hypoxia effects across the two PAT variables of interest showed significant and large effects. Tracking only (low workload) resulted in a significant main effect for hypoxia, $F(2,24) =$

$18.194, p < .001$, partial $h^2 = .43$. The composite score of full PAT performance (high workload) showed a significant main effect for hypoxia, $F(2, 24) = 14.630, p = .001$, partial $h^2 = .362$ and a significant stress by time interaction $F(2, 48) = 3.477, p = .039$, partial $h^2 = .127$. CogScreen VSC showed a significant hypoxia effect, $F(2,24) = 27.218, p < .001$, partial $h^2 = .564$, but did not show a significant hypoxia by time interaction.

DISCUSSION: The PAT is sensitive to the performance effects of hypoxia across both high and low workload measures. The observed stressor by time interaction for full PAT suggests that hypoxia performance effects get larger as time at altitude increases. CogScreen VSC showed the highest effect size but was not sensitive to the cumulative effect of hypoxia associated time at altitude.

Learning Objectives

1. Understand what it means for a measure of human performance to possess criterion validity within the context of aviation related environmental stress?
2. Understand the important characteristics that measures of human performance must possess in order to be relevant in aviation environmental stress testing.
3. Understand how to determine whether human performance effects found in research are relevant to a given operational context?

[249] SYNTHETIC WORK (SYNWIN) PROGRAM TO TRACK COGNITIVE CHANGES DURING HYPOXIC STRESS

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(Education - Tutorial Proposal)

PROBLEM STATEMENT: When developing an aircrew monitoring system to mitigate physiologic episode risk, it is critical to relate changes in physiological response to degraded cognitive state. NAWCAD uses SynWin (ver 1.2.39, ARS, Chula Vista, CA) to track this in real time. **TOPIC:** SynWin (3) provides a generic work environment where subjects are required to remember and classify items on demand, perform an arithmetic task, and monitor and react to visual and auditory prompts. It presents four simultaneous tasks on a computer screen, one per quadrant. Subjects use a mouse to enter responses. Each task is customizable for difficulty and data sampling rate. The tasks are: **1. Sternberg memory task (SMT):** Displays a string of 2-6 upper-case letters for 5s, which subjects memorize before disappearing. Then, a single letter randomly appears (up to 20s), and subjects indicate if it was part of the string or not. Score is based on accuracy, reaction time (RT), misses, and peeks (displays the string). **2. Math task:** A self-paced task to add 2-3 random three-digit numbers, using a mouse to enter the sum. Score is based on accuracy and response time (RESP). **3. Visual monitoring task:** Subjects are presented with a gas gauge that they must click to "refill tank" before it is empty. Points are awarded proportional to proximity to 0 and are deducted for each second the pointer is at 0. Score is based on the number of lapses and how consistently the gauge is reset. **4. Audio vigilance task:** Short individual tones (1000Hz and 2000Hz) are presented for 0.15s every 10-20s. The task is to click a button when subjects detect the higher pitch. Score is based on accuracy, RT, and misses. A Composite score is calculated as the sum of the four task scores. **APPLICATIONS:** Over 100 datasets have been collected under normobaric and hypobaric exposures up to 7620m since 2014 (1). Math accuracy and RESP are the most sensitive to these exposures. For example, in a 2018-19 hypobaric study with nine consented volunteers exposed to 5335m while breathing air, math score dropped by $52 \pm 27\%$ and RESP increased by $62 \pm 58\%$ vs. SMT score increasing by $8 \pm 30\%$ and RT rising by $9 \pm 20\%$. Math metrics have been used along with real-time changes in pulse oximetry as inputs to a USN neurological model (2) to develop an index of cognitive degradation (3). **RESOURCES:** (1) AMHP 2017. 88(7):616-26; (2) IEEE Trans BME 1988. 45:1017; (3) Behav Res Meth Inst Comp 1994. 26(4):421-6; (4) AMHP 2019. 90(3):249

Learning Objective

1. To understand how SynWin has been used to quantify cognitive deficit during hypoxia exposures.

[250] THE USE OF A MOBILE COMPUTERIZED NEUROCOGNITIVE SCREENING TEST TO DETERMINE RETURN TO FLIGHT AFTER A NEUROLOGIC INSULT IN NAVAL AVIATORS

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(Education - Tutorial Proposal)

INTRODUCTION: Subtle neurocognitive changes after neurologic insults can be missed through gross medical examination, particularly in high functioning personnel such as aviators. A situation where an illness or injury has an adverse impact on cognitive functioning is where neurocognitive assessment is indicated. Neurocognitive evaluation data has provided both general and specific information about current levels of cognitive performance and can indicate level of recovery or need for further treatment. **TOPIC:** The US Navy has conducted research to determine cause and potential future ramifications of cognitive changes due to Physiologic Episodes (PEs) with military pilots in high performance aircraft. In order to return to flight following a PE, a pilot must be asymptomatic from all physical and neurocognitive symptoms. One way to assess cognitive recovery from these symptoms is comprehensive neurocognitive testing, however most comprehensive testing lasts several hours and far from the environment where military aviators fly. Screening tests can indicate if more comprehensive evaluation is even necessary. Computerized screening tests can be administered by trained medical personnel deployed with aviators such as aerospace medicine technicians or flight surgeons embedded in squadrons or aboard air craft carriers. A detailed review of a mobile, computerized neurocognitive screening test will be discussed; including historical development, extensive normative data collection, recent operational validation studies and its use in research with hypoxia and rapid cockpit pressure fluctuations. The successful application and implementation of this test in Naval Aviation to determine an aviator's ability to return to flying after neurologic insult while deployed to remote operational environments will be reviewed. **APPLICATION:** Neurocognitive testing has been shown to be sensitive and specific for subtle cognitive changes in pilots after neurologic insult. Utilizing brief, computerized neurocognitive screening tests in the operational environment can determine if further evaluation is required to decrease downtime for an aviator and overall disruption of the mission. Data show the successful implementation of this computerized screening test is a key component to determine when a pilot who suffered neurologic insult requires medical evacuation or can return to flying. **RESOURCES:** (1) AMHP 2019. 90(2) 92-100; (2) NEDU TR 19-04. 2019: 3-74.

Learning Objective

1. The participant will be able to understand how computerized cognitive screening tests can be used for an aeromedical determination in a deployed environment.

[251] TEST-RETEST RELIABILITY OF THE US AIR FORCE PERFORMANCE ASSESSMENT TOOL

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(Original Research)

INTRODUCTION: In an attempt to develop a rapid cognitive-perceptual task that is sensitive to the effects of stressors while also having high operational face validity, the USA Air Force School of Aerospace Medicine (USAFSAM) developed the Performance Assessment Tool (PAT). The PAT is designed to rapidly assess cognitive performance and is based on a cognitive task analysis specific to aviation; this analysis suggested that four tasks would be sufficient to measure the cognitive attributes required for aviation: tracking, math, short-term memory, and mannequin. PAT development occurred in three iterations, the second was tested in an academic setting; this informed the third iteration, tested here. PAT is a

computerized test that requires "multi-tasking;" there is a primary tracking task with simultaneous presentations of three different secondary tasks. The current study was performed to provide an evaluation of PAT (version 3) test-retest reliability across twenty sessions conducted over two days.

METHODS: Twenty-five student Naval Aviators at Naval Air Station Pensacola, FL participated in the study. All were men with ages ranging from 22 to 29 years ($M = 23.48$ years, $SD = 1.56$ years). Participants performed 24 iterations of the PAT across two days. Several dependent variables were assessed, including performance on tracking, math, mannequin, memory, and two composite scores called PAT Composite and PCOLA Composite (PCOLAC). Cronbach's alpha was calculated as a measure of internal consistency or reliability for each variable across the last ten Day 1 sessions, across the last ten Day 2 Sessions, and across 20 sessions.

RESULTS: Day 1 reliability scores were generally low. By contrast, Day 2 scores were higher: Cronbach's alpha for the PAT Composite Score was 0.733, with PCOLAC=0.927 and Tracking=0.917. Reliability analysis across the 20 sessions from Days 1 and 2 shows good reliability for Tracking (0.890) and PCOLAC (0.811). **DISCUSSION:** PAT variables possessed low reliability across the first 10 sessions completed during Day 1. Conversely, the reliability of PAT improved dramatically across the second 10 sessions completed on Day 2. PCOLAC and PAT Tracking showed excellent reliability, while the PAT Composite showed good reliability. In total, the results demonstrate that PAT possesses high internal consistency and is more than adequate to use in human performance and stress work.

Learning Objective

1. Understand the attributes of a novel rapid cognitive performance assessment task.

[252] USING THE NASA MULTI-ATTRIBUTE TASK BATTERY WITH PSYCHOPHYSIOLOGICAL ASSESSMENT

Kellie Kennedy¹, Chad L. Stephens¹, James R. Comstock¹,

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(Education - Tutorial Proposal)

INTRODUCTION: The Multi-Attribute Task Battery (MATB-II) developed at NASA Langley Research Center (LaRC). The MATB is a computer-based task designed to evaluate operator performance and workload. MATB provides a benchmark set of tasks and analogous to activities that aircraft crew-members perform in flight, with freedom to use by non-pilot subjects. The performance of multiple tasks is a central feature of the MATB and it is this feature that is consistent with most operational systems and thus makes the task useful for our purposes as a research platform. Development of the original and current MATB as well as implementation of the biocybernetic capability will be covered. **TOPIC:** The MATB requires rapid task-switching to perform monitoring, dynamic resource management, and tracking tasks in near-simultaneous operation with a composite score calculated from the sum of the four task scores.

System Monitoring: Simulates the demands of monitoring gauges and warning lights. **Tracking:** Simulates the demands of manual flight control to keep the target at the center target point. **Communications:** Determine which messages are relevant and to respond by selecting the appropriate radio and frequency on the communications task window. **Resource Management:** Toggle any of the eight fuel pumps to maintain balanced fuel and respond to pump failures. **APPLICATIONS:** The MATB has been used in hundreds of studies to examine work behavior or sustained performance across various research subdisciplines and in applied settings such as the hypoxia training environment. One use configured the automation state of the Tracking subtask to be driven by an operator engagement index derived from EEG in real-time. This novel capability enabled brain-computer interface methodologies to expand into adaptive neurotechnologies. The closed-loop configuration allowed psychophysiological assessment of cognitive performance and real-time adaptation of the sub-task difficulty levels in response to the operator engagement state. The results of previous studies will be presented to demonstrate the efficacy of MATB as a research tool across a wide range of application areas. The potential applications of MATB as a standalone test for cognitive performance testing will be considered. Additionally, the possibility of combining the MATB with other cognitive performance tests will be discussed. Finally, a discussion of conceptual MATB configurations will be included in the proposed presentation.

Learning Objective

1. To understand how to use the MATB-II for subject response data.

Wednesday, 05/20/2020
Exhibit Hall

10:00 AM

[S-53]: POSTER: CLINICAL MEDICINE

Chair: Tamara Averett-Brauer

Co-Chair: Nora Johnson

[253] METABOLIC DISORDER IN US ARMY AVIATORS: REVIEW OF RECENT TRENDS 2016-2018

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(Original Research)

INTRODUCTION: Recent epidemiological studies of U.S. Army aviators have suggested higher than anticipated rates of hyperlipidemia and metabolic disorder. The goal of this study was to determine whether this finding had persisted in 2016-2018 and whether this required further evaluation in the military aviation/aeromedical communities. **METHODS:** Using appropriate ICD-10 codes, data on rates and percentages of hyperlipidemia and metabolic disorder in U.S. Army aviators during the period 2016-2018 were requested from the U.S. Army Aeromedical Electronic Resource Office (AERO) and the Defense Medical Surveillance System (DMSS). Age stratified rates for these conditions were also sought from DMSS. Descriptive statistics were used to present the results. No formal analyses were conducted. **RESULTS:** Results from DMSS showed overall rates of hyperlipidemia ranging from 3.18 to 6.83 per 1000 person-years and for metabolic syndrome from 0.16 to 0.69 per 1000 person-years. This compares to previously reported rates of 4.05 and 0.43, respectively. The age stratified rates increased proportionally with age. AERO data showed a range of 0.8 to 1.5% of aviators had hyperlipidemia and for metabolic syndrome this ranged from 0.31 to 0.45%, compared to 3.9 and 3.4%, respectively, from another of the previous studies.

DISCUSSION: The figures from DMSS and AERO do not portray an increasing trend of these two diagnoses in the aviator population. Additionally, the age stratified rates are generally consistent with those expected with aging in the general population. This suggests that further evaluation or exploration by the aeromedical community is not necessary. While the exact cause is unknown, the higher rates seen previously may be down to screening and detection bias. Limitations include incomplete matching of search criteria to the previous studies and reliance on correct data entry into DMSS and AERO.

Learning Objectives

1. The participant will learn about the prevalence of metabolic disorder in US Army aviators.
2. The participant will be made aware that current prevalence of metabolic disorder does not show an increasing trend from previous years and that it generally mirrors that found in the general population.

[254] ASSESSING PRIMARY CARE PREDIABETES MANAGEMENT AND DIAGNOSIS AT DAVID GRANT MEDICAL CENTER (DGMC)

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(Original Research)

INTRODUCTION: Type 2 diabetes mellitus (T2DM) contributes to significant morbidity, mortality, and healthcare costs in the U.S. and is a disqualifying condition for military recruitment and USAF servicemembers. T2DM can be prevented if patients with prediabetes achieve modest weight loss, exercise, and/or take metformin. Though the ADA and USPSTF recommend lifestyle counseling and/or metformin for prediabetic patients, only 23% of primary care physicians (PCPs) provide these nationwide. Given this nationwide gap in prediabetes care by PCPs, this study evaluated how well PCPs at David Grant Medical Center, Travis AFB, CA (DGMC) are diagnosing and managing prediabetes to prevent T2DM. **METHODS:** Original cross-sectional research project created by DGMC

intern analyzing all encounters of adults 18 years and older, both active duty (3%) and non-active duty, 56% female, at any DGMC primary care clinic (Flight Medicine, Internal Medicine, Family Medicine, Family Health) from 1/1/2016-11/30/2018 with an ICD-10 code of prediabetes, impaired fasting glucose, and/or impaired glucose tolerance as well as hemoglobin A1c (HbA_{1c}) within the range of 5.7% to 6.4%. The primary outcome measure was treatment for prediabetes, which included diet and/or exercise counseling by a PCP, nutrition referral, and/or a metformin prescription (n=2377). Logistic regression was performed to assess the effect of HbA_{1c} level and other patient characteristics on receiving treatment for prediabetes. Prediabetes diagnosis was also assessed using data from all adults with a HbA_{1c} test within 5.7%-6.4% from 1/1/2016-11/30/2018 (n=3390). IRB approved. **RESULTS:** 26% of all prediabetic patients and 30% of active duty patients received correct management. Obese patients and those with HbA_{1c}% >6% were more likely to receive treatment ((OR 1.8 (1.3-2.4 95%CI), 1.4 (1.1-1.8 95%CI), respectively)), while males were less likely to receive treatment (OR 0.8 (0.6-0.97 95%CI)) in multivariable analyses. 59% of adults with prediabetic HbA_{1c}% were diagnosed with "prediabetes" during a PCP encounter. **DISCUSSION:** Only 26% of all patients and 30% of active-duty patients with prediabetes were properly managed according to guidelines, similar to national level data, and only 59% were diagnosed. Factors preventing proper primary care prediabetes diagnosis and management should be identified and rectified to increase service-member retention and reduce long-term healthcare costs.

Learning Objective

1. The audience will learn about prediabetes primary care diagnosis and management at an Air Force MTF (DGMC).

[255] ASSESSING CHARACTERISTICS OF ACTIVE AIRMEN TRANSITIONING TO BASICMED

Endorsed by the American Society of Aerospace
Medicine Specialists

Valerie Skaggs¹, Ann Norris¹, Thomas Chidester¹

¹FAA/CAMI, Oklahoma City, OK, USA

(Original Research)

INTRODUCTION: Medical conditions and special issuance (SI) status in the active third-class US civil airmen population changed drastically in 2018 when compared with 2016. BasicMed became effective May 1, 2017, and this study's objective was to determine how the change in active third-class airmen has shifted to the BasicMed population. **METHODS:** Medical certification records from 2011-2018 were selected from the Federal Aviation Administration's (FAA) Document Imaging Workflow System (DIWS). Medical data were abstracted from the most recent medical examinations, with the exception of medical conditions that were historical and current. Medical certificate validity was determined as of 12/31/2016 and again as of 12/31/2018. Those airmen that held a valid medical at the end of 2016 but not in 2018 were considered no longer active. This group of non-active airmen was then merged with the FAA Civil Aviation Registry Airmen Certification Branch dataset to determine who had declared the intention to fly under BasicMed. **RESULTS:** In 2016, there were 243,400 active third-class airmen with an average age of 44.7 (STD=18.0). In 2018 this number decreased to 205,144, with an average age of 42.4 (STD=17.8). Of those active in 2016, 101,317 (41.6%) were no longer active in 2018, and of these 25,923 (25.6%) declared the intention to fly under BasicMed. The average age of those who transitioned from the 2016 active group to the BasicMed group was 61.0 (STD=11.4), while the remaining group that became inactive was only 48.8 (STD=18.1). In 2016, 7.7% of active airmen held an SI, and this percentage decreased to 5.8% in the 2018 active group. However, 27.4% of the study's BasicMed group held an SI in 2016. The number of airmen who reported medication-controlled diabetes in 2016 was 4,659. This decreased to 2,861 in 2018, while 1,926 airmen with diabetes were shifted to the BasicMed group. For myocardial infarctions, the number in 2016 changed from 1,798 in 2016 to 947 in 2018, with 894 from the 2016 active airman population shifting to the BasicMed group. **DISCUSSION:** The change of the active third-class population's medical conditions and SIs can be, at least in part, attributed to BasicMed. Many of the medical conditions that require an SI have numbers that have been reduced by half in just a two-year time span. This may represent a hazard to the National Airspace System. This data will contribute to the required Congressional report.

Learning Objectives

1. The participant will be able to discuss the changes in characteristics in the third class airmen population from 2016 to 2018.
2. The participant will be able to see some of the impact due to the implementation of BasicMed on the active third class airmen population from 2016 to 2018.

[256] THE RISK OF MELANOMA IN ITALIAN PILOTS AND AIR CREW

Sara D'Epiro¹, Luca Melis¹, Margherita Biele¹, Emilia Buccino¹, Valeria Vinci¹

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(Original Research)

INTRODUCTION: Several meta-analysis recently investigated the incidence of melanoma and non-melanoma skin cancer in pilots and cabin crew members. The increased risk of skin cancer seems to be associated with the exposure to UV and to ionizing cosmic radiation at flight altitudes. **METHODS:** 8234 Pilots and crew members were included in the cohort and studied over a period of five years (2015-2019). The observed cases were compared to the expected case in general population, with data obtained from the national epidemiology registry. Chi-squared test was used to compare the observed data with the expected data. **RESULTS:** 508 diagnosis of skin cancer were made, in particular 208 cases of melanoma and 300 cases of non melanoma skin cancer. 208 cases/8234 of malignant melanoma were observed with an incidence of 2.5%. The ratio between the observed and expected case is 1.7 (SIR). The comparison of the two data calculated using chi square test (21.68) resulted statistically significant (p value < 0.05). **DISCUSSION:** Flight-based workers are thought to have a greater occupational hazard risk of melanoma owing to increased altitude-related exposure to UV and cosmic radiation. The pathogenic role of UVA in melanoma is well established. The windshields and cabin windows of airplanes seem to minimally block UVA radiation, and at 9000 m, where most commercial aircraft fly, the UV level is approximately twice that of the ground. It is possible that other unmeasured confounders may account for higher melanoma risk in pilots such as history of sunburn, sunbed usage, sunscreen used, or number of sunny vacations when comparing pilots and cabin crew with the general population. **CONCLUSIONS:** In agreement with previous findings, we found that SIR for pilots and cabin crew was 1.7, indicating that pilots and air crew have higher incidence of melanoma compared with the general population. This has important implications for occupational health and protection of this population.

Learning Objective

1. The increased risk of skin cancer seems to be associated with the exposure to UV and to ionizing cosmic radiation at flight altitudes. This has important implications for occupational health and protection of this population.

[257] IN-FLIGHT PRESYNCOPE IN A FIGHTER PILOT AND THE INTEREST OF THE AUTONOMIC NERVOUS SYSTEM EXPLORATION: A CASE REPORT

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¹Military Hospital of Instruction Mohammed V, Rabat, Morocco

(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: this case report describes a fighter pilot who presented an in flight presyncope. The autonomic nervous system exploration by Ewing's tests revealed a vagal hyperactivity associated with an alpha sympathetic deficiency, suggesting the vasovagal mechanism of syncope. **BACKGROUND:** the autonomic nervous system is highly solicited during +gz accelerations on high performance aircraft, hence the interest of its exploration by Ewing's cardiovascular reactivity tests which give the complete autonomic profile. Vasovagal syncope is generally benign, but in aviation environment, the association with dysautonomia, can seriously affect the flight safety. **CASE REPORT:** a 27-year-old fighter pilot, with 870 total flying hours, and without medical history, presented an in-flight presyncope on alphet. The initial clinical examination was normal, as well as the cardiovascular and biological check-ups. The exploration of the autonomic nervous system by Ewing's tests revealed hypervagotonia, with

an alpha sympathetic central and peripheral deficiency. Furthermore, this pilot reports some professional conflicts with psychological repercussions on his motivation. **DISCUSSION:** the presyncope is a minor equivalent of syncope, and requires the same diagnostic approach. The dysautonomic profile of the pilot as well as the autonomic activation prodromes, that preceded the malaise, suggest a vasovagal origin of this presyncope, especially since, on board a fighter aircraft, +gz accelerations reproduce an extreme orthostatic stress situation, often implicated in the physiopathology of vasovagal syncope. In addition, non-specific aeronautical factors, like aviation stress and fatigue, affect the response of the sympathetic system. Psycho-social factors, also seem to be involved in triggering these vasovagal reactions. In view of this dysautonomic background and the association with psychological disorders, the pilot was declared unfit to fly. This observation highlights the importance of Ewing's cardiovascular reactivity tests, to identify the autonomic profile of aircrew, especially fighter pilots, whose autonomic nervous system is constantly solicited. Psychological evaluation, also seems important in case of a vasovagal syncope in aircrew.

Learning Objective

1. Importance of autonomic nervous system exploration in case of fighter in-flight presyncope.

[258] ATRIAL SEPTAL DEFECT IN AN AIRCREW

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(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: The case report describes a AWACS Aircrew having diagnosed with Atrial Septal Defect becoming symptomatic. **BACKGROUND:** CHD can be simple to complex. Advances in Rx have led to improved mortality. Some CHD conditions may present in those with already flying duties. Appropriate occupational risk assessment has become paramount to ensure flight safety. **CASE PRESENTATION:** 28 yr old aircrew with 5yrs service in AWACS presented to Flight line Clinic in Oct 2018 with Chest pain on and off for one week. Pain was mild in intensity pricking in nature aggravated by climbing stairs or exertion. Associated with mild shortness of breath as well. Assessed by Cardiologist with echo and TEE as well where he was told that he has OS ASD around 2.5cm with left to right shunt, with severely dilated right atrium and right ventricle. The patient was operated for ASD on January 2019 thru angiography. And placed on Aspirin for 6 months and told to avoid exertion and given follow up after 6 months. Cardiologist opinion post 8 months Post ASD was good LV function EF 55%. Normal right side with no pulmonary hypertension. Can resume his normal activity and work. the patient expressed concerns for his health and return to flying duties as he mentions that on occasions he would get symptomatic with mild chest pain and shortness of breath. ECG was normal Echo showed no residual shunt and LVF 50%. O2 sats 100%. Plan: follow up and Holter and echo. NO SBE prophylaxis. Advised no physical exertion and continue aspirin till then. **DISCUSSION:** This 28-year-old patient showed good post-surgery outcome but regard to flying category concerns were 1) late closure of ASD is associated with a poorer outcome due to AF, thromboembolism and onset of RHF 2) The risk of hypoxia equivalent to heavy exercise and risk of rapid decompression, if he goes back flying 3) Preop echo with dilated right atrium and ventricle. Needs of meds currently and in future 4) Advise to avoid strenuous physical exercise. It is decided to ground the aircrew with regular follow up.

Learning Objective

1. The participant will learn About Occupational risk assessment of Aircrew with ASD.

[259] OUTCOME OF A POLICY OF SELECTIVE RECERTIFICATION OF PILOTS WHO HAVE UNDERGONE A CARDIAC TRANSPLANT

Ann Norris¹, Valerie Skaggs¹, David Kaye², James DeVoll³, David McGiffin²

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(Original Research)

INTRODUCTION: From 2007, third-class airmen in the USA who received a heart transplant could apply for recertification under special

issuance. This policy change was based on results of a clinical study that demonstrated if criteria were met, risk of sudden death over the year following evaluation was sufficiently low to safely allow qualifying pilots to return to flying. The study's objective was to evaluate certification safety and determine any adverse outcomes in this group of transplant recipients.

METHODS: Methods involved collecting data from the Federal Aviation Administration Document Imaging Workflow System to identify airmen undergoing cardiac transplantation since 2007, examining medical and safety-related outcomes through the National Transplantation Safety Board's accident database and the Centers for Disease Control and Prevention National Death Index. Means, frequencies, and distributions of certification variables were compared between those issued a certificate and those denied one. **RESULTS:** Thirty-six airmen were included in the study, with 16 recertified and 20 denied certification. The mean age at the time of transplantation of the 16 airmen who were recertified was 59.3 years (std dev=15.43), compared with mean age of 57 years (std dev=11.79) of the 20 who were denied certification ($p=0.6101$). The mean certification time of these 16 airmen based on time from first successful recertification after transplantation to time until their last medical examination in the system was 2.5 years (std dev= 2.99). No aviation accidents or recorded deaths occurred in the group of 16 airmen undergoing recertification. Thirteen of these airmen underwent a second successful recertification and 6 underwent a third attempt, with 5 being successful. Two airmen have declared their intention to fly under BasicMed. Of the 20 airmen denied recertification, 16 were denied for failure to provide information. There were 3 deaths in this denied group. **DISCUSSION:** Policy allowing third-class heart transplant recipient recertification is safe, and it is possible the policy may be overly conservative. Aviation safety is not being compromised by allowing these airmen to resume flying. BasicMed rules require heart transplant recipients to undergo one-time evaluation for Special Issuance of a medical certificate. However, there are limited data on heart transplant recipients flying under BasicMed on which to assess risk to the National Airspace System.

Learning Objectives

1. The audience will learn about the 2007 change in Aerospace Medicine policy, allowing heart transplant recipients to continue flying under a special issuance.
2. The audience will learn about medical and safety-related outcomes of heart transplant recipients who applied for medical certification after 2007.

[260] DEGENERATIVE CERVICAL SPINE CHANGES AMONG FINNISH FIGHTER PILOTS IN A 5-YEAR FOLLOW-UP

Tuomas Keskimölä¹, Tuomas Honkanen², Jaakko Niinimäki³, Jaro Karppinen⁴, Tuomo Leino⁵
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(Original Research)

INTRODUCTION: Neck pain causes often disability among Finnish Air Force (FINAF) fighter pilots and may lead to reduced cervical functional ability and thereby to flight duty limitations. Moreover, it has been suggested that degenerative changes of the cervical spine may be related to neck pain. The aim of the study was to determine the association of G exposure with degenerative cervical spine changes among the fighter pilots. **METHODS:** The degenerative changes of cervical spine (from C2 to T1) were assessed by magnetic resonance imaging (MRI). The study population consisted of 56 volunteered FINAF male fighter pilots (age: 21 (± 0.6) at the baseline) and 38 Army and Navy cadets (age 22 (± 0.8) at the baseline) from the National Defense University as controls. The MRI examinations were collected at the baseline and after 5 years of follow-up for both populations. The degree of disc degeneration was assessed using Pfirrmann classification (five grades consisting of evaluations of disc space height, disc homogeneity, nucleus intensity and distinction between nucleus and annulus) and disc herniations. **RESULTS:** Mean Pfirrmann score of the entire cervical spine for the fighter pilots was 2.2 (± 0.3) at baseline and 2.5 (± 0.3) at follow-up. The corresponding scores for the control population ($n=37$) were 2.3 (± 0.4) and 2.6 (± 0.4). The average number of herniations per individual for the fighter pilots was

0.23 (± 0.5) at baseline and 0.45 (± 0.6) at follow-up. The corresponding averages for the control population were 0.08 (± 0.4) and 0.21 (± 0.6).

DISCUSSION: According to present findings, there was a minor progression of disc degeneration and a slight increase in the prevalence of disc herniations among both fighter pilots and non-flying military academy students. However, there was no significant difference between the groups which may be explained by relatively low G exposure during the first five years of pilots' career. We recommend future studies to investigate this association with longer follow-up periods.

Learning Objective

1. To acquire a better understanding on the relation between G exposure and cervical spine degenerative changes.

[261] IMPACT OF TERRAIN ON OPTOKINETIC CERVICAL REFLEX: A PRELIMINARY STUDY

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(Original Research)

INTRODUCTION: Optokinetic Cervical Reflex (OKCR) is a physiological phenomenon experienced by pilots, seen as head tilt in the opposite direction of the aircraft's bank. It is assumed that OKCR helps pilots keep the moving horizon level in the pilot's retina, which maintains spatial orientation. Our previous study showed that OKCR is dependent on altitude; as the altitude increased, OKCR decreased. The aim of this study is to see whether the type of terrain being flown over has an impact on OKCR. **METHODS:** 4 pilots (3 male and 1 female) flew two 15-minute flights using a desktop flight simulator equipped with a large visual display. The 'Terrain Flight' was conducted in the Alpine Valley of Switzerland. The 'No-Terrain Flight' was conducted over the Mediterranean Ocean. Both flights were conducted below 1,500 feet above ground level (AGL). Head tilt was recorded with a MPU 6050 gyroscope and accelerometer attached to a standard pilot communications headset with a data sampling rate of 100 Hz. Flight data was recorded via a data capturing software program at a capture rate of 8 Hz. This study received institutional ethics approval. **RESULTS:** Aircraft bank caused head tilt in the opposite direction during both the flights, consistent with OKCR. The aircraft bank angle ranged between -90° to $+90^\circ$. The head tilt angle ranged between -16° to $+23^\circ$. The overall means of the head tilt angle were compared for the 'Terrain' and 'No Terrain' flights. The results showed that there was no statistically significant difference between the head tilt for both the flights; $F(1, 360) = 2.849, p > 0.05$. **DISCUSSION:** Terrain at low altitude had little impact on OKCR. Our previous study showed that altitude had an impact on OKCR. These studies combined show that OKCR is prevalent at lower altitudes, regardless of the landscape a pilot is flying in. As the aircraft climbs higher, the effects of OKCR reduce. This further supports the conclusion that OKCR is a visually based reflex at lower altitude. Being a preliminary study, further research is needed to better understand this phenomenon.

Learning Objective

1. Participants will be educated about Optokinetic Cervical Reflex during low altitude flight.

[262] AN ADJUSTABLE, LED-BASED GLARE SOURCE WITH POTENTIAL CLINICAL AND OCCUPATIONAL SCREENING APPLICATIONS

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(Education - Tutorial Proposal)

INTRODUCTION: Glare, whether from sunlight or artificial light sources, is a ubiquitous issue for vehicle operators. The issues presented by glare for aviators are even greater than those experienced by terrestrial vehicle operators due to increased elevation, reduced atmospheric filtering, a greater need for situational awareness, higher velocities (resulting in reduced reaction time windows), and the requirement to maintain specific aircraft orientations or flight corridors. **TOPIC:** Corneal surgeries (such as LASIK and PRK) often create greater glare sensitivity as a side effect. These procedures are becoming increasingly common among aviators and military aviation has led the

adoption in an effort to expand candidate eligibility for flight schools and maintain visual performance of pilots. A novel LED-based glare source was developed at the USA Army Aeromedical Research Laboratory (Fort Rucker, AL) as an experimental device for quantifying human visual performance. It has the capability to precisely and repeatedly create a wide array of different glare conditions for testing visual performance. The commercially available equipment for testing glare disability is focused on individuals with suspected cataracts and generally are not optimized for testing younger adults whose vision is generally healthy and these devices offer little or no flexibility in testing methods. This new device allows for the creation of glare intensities ranging from negligible to completely obscuring vision and permits the angular orientation of a glare source to be adjusted electronically. **APPLICATION:** This apparatus has potential additional applications including: training service members to conduct operations during glare conditions, quantifying pre- and post-procedure glare sensitivity to improve future corneal surgeries, selecting individuals for clear-lens replacement surgeries to improve occupational safety, testing for light sensitivity issues after traumatic head or eye injuries, and identifying candidates with exclusionary glare-sensitivity related issues in relevant military occupational specializations.

Learning Objective

1. The participant will become familiar with a novel apparatus for assessing glare disability and potential clinical and/or aviation applications for the device.

[263] PREVALENCE OF KERATOCONUS IN APPLICANT MILITARY PILOTS OF ITALIAN ARMED FORCE

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¹Italian Air Force, Rome, Italy

(Original Research)

INTRODUCTION: Keratoconus is a non-inflammatory corneal ectasia, characterized by progressive corneal thinning, protrusion and scarring. The literature on keratoconus disclosed that prevalence and incidence vary widely depending on diagnostics criteria, geographic area and groups of patients selected. The aim of this study is to determine the prevalence rate of keratoconus in a cohort of applicant military pilots. **METHODS:** All patients diagnosed with keratoconus since 2017 to 2019 during enrollment medical examination to become military pilots were included in the study. The mean age of diagnosis was 23 years and 93% of diagnosed patients were male. We visited 2376 applicants. The diagnostic tools we used were keratometer, pachymeter, topographer and aberrometer for each candidate. The prevalence of diagnosed keratoconus was calculated and then compared with rates of prevalence in general European population using chi-square test. **RESULTS:** This study included 2376 participants and keratoconus was diagnosed in 15 of them. The prevalence rate in our population was 0.6%. The estimated prevalence of keratoconus in the general European population was 1:375 (0.26%). The comparison between registered and expected cases performed using chi-square test (3.87) resulted statistically significant (p value < 0.05) and showed a ratio of 2.5 (SIR). These values are 2-fold higher than ones in reference study.

CONCLUSION: The results of this study showed that in the cohort we observed, keratoconus prevalence rate was higher than general population living in the same geographical area. With new imaging modalities and a better comprehension of the disease, keratoconus was diagnosed more often and earlier than in the past. In our cohort we confirmed this tendency and diagnosed even subclinical disease. Since keratoconus is an underestimated and low-progression eye disease, high sensitivity diagnostics could avoid to recruit personnel at risk for future unfitness.

Learning Objective

1. Prevalence of keratoconus is higher in military pilots undergo high sensitivity diagnostics than in civilian cohorts.

[264] RABIN CONE CONTRAST COLOR VISION TEST REPEATABILITY INDICES

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(Original Research)

INTRODUCTION: The repeatability of the INNOVA Systems (Burr Ridge, IL) Rabin Cone Contrast test for normal color vision is reported to be excellent (Chay et al. 2019). However, there is little information available as to the repeatability of the test for a cut-off score of 55 that allows individuals with mild color vision defects qualify as pilots in the USA Air Force and Navy. There is also little information available as to the between-session repeatability for the sensitivity of each eye. The purpose of this study is to determine these values. **METHODS:** Monocular chromatic thresholds were measured for the L-cone, M-cones, and S-Cones. Sixty color-normal (CVN) subjects and 68 subjects with a red-green color vision defect (CVD) participated. Color vision was classified using the Rayleigh color match. Ninety-three percent of the CVNs and 86% of the CVDs returned within 10 to 15 days to repeat the test. **RESULTS:** The between-session AC1 coefficient of agreement in terms of normal/abnormal red-green color vision was 0.97 (95% CI of 0.92 to 1.0). The between-session repeatability for the 55 cut-off was lower at 0.88 (95% CI of 0.80 to 0.97). The lower repeatability was primarily due to 45% of the CVD who passed the first session, but failed at the second session. Because the between-eye and session differences were not normally distributed, the limits of agreement (LOA) between eyes and the coefficients of repeatability (COR) between sessions were based on the median differences and the 2.5 percentile and 97.5 percentile scores, The median values for the between-eye differences and the between-session differences were all near zero. The CVN between-eye LOAs were -10 to 15 units for the L cone, ± 10 units for the M-cone and -5.0 to 10 units for the S-cone. The CVN between-session CORs were similar for the respective cone mechanisms. The deutan LOAs and CORs were -30 to 40 units for the L-cone and -45 to 40 for the M-cone. The protan LOAs and CORs were -25 to 60 for the L-cone and -30 to 20 for the M-cone. The S-cone LOAs and CORs were ± 10 units for both the protans and deutans. **CONCLUSION:** The CVN LOAs were slightly lower than the previous results. The LOA and COR for the CVDs were at least 3 times larger than the CVN values for the L and M-cone stimuli, but similar to the CVN values for the S-cone. This between-session variability could be sufficient to erode the repeatability of the test when using a cut-off score of 55.

Learning Objectives

1. Understand the overall repeatability of the Cone Contrast Test for the two pass/fail scores.
2. Understand the between-eye and between-session limits of agreement.

[265] THE RELATIONSHIP BETWEEN HEART RATE AND WORKLOAD LEVEL ON A VISUALLY DEMANDING FLIGHT TASK: IMPLICATIONS FOR OPERATOR STATE MONITORING

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(Original Research)

INTRODUCTION: A promising method for monitoring workload in real time is through the use of psychophysiological recording devices. Some of the commonly used psychophysiological measurements of workload include electrocardiogram (ECG) for cardiovascular measures (e.g., heart rate, heart rate variability, blood pressure (Stuiver et al., 2014)). Such measures are able to provide indications of the mental or physical engagement of the individual that correspond to changes in task demands. Wickens (2002, 2008) Multiple Resource Model postulates that the relationship between workload and performance is driven by the degree of overlap in resources required across four dimensions. To apply this framework to aviation, we refined description of these four discrete domains to be more directly representative of the categories encountered during aviation: visual, auditory, cognitive, and physical. In this study, we explored the predictive validity of cardiovascular measures for workload levels during a simulated flight task. **METHODS:** Twenty-three U.S. Army rated, rotary-wing pilots were recruited from the Fort Rucker, AL area and completed simulated flights where workload was manipulated in the visual domain. Specifically, participants completed a terrain flight with full visibility in daytime conditions (low workload) and limited visibility in nighttime conditions (high workload). **RESULTS:** Results from a binary logistic regression showed that baseline-corrected heart rate was a significant predictor of workload level such that the increased heart rate predicted high workload. Additionally, scores on the NASA TLX

differed between conditions suggesting successful manipulation of workload between high and low level conditions. **DISCUSSION:** These results provide initial support for use of cardiovascular measures to detect changes in workload relative to the visual domain. Based on these results it can be concluded that there is plausibility for measuring distinct physiological changes in response to workload demands within a resource domain.

Learning Objective

1. Understand the construct validity of heart rate as a measure of workload.

[266] PANORAMIC VIEWS WITH SECOND-GENERATION TRIFOCAL INTRAOCULAR LENSES

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(Education - Tutorial Proposal)

INTRODUCTION: Advances in aviation technology often place rigorous demands on aviators' vision. These demands, amplified further when aviators develop age-related vision changes, necessitate glasses, contact lenses, or surgical intervention to enhance aviators' quality of vision to adhere to FAA requirements. Second-generation trifocal intraocular lenses (IOLs) have been an incredible enhancement to quality of vision, depth perception, and peripheral field of view compared to previous corrective measures. Novel IOLs will likely become the future treatment option of choice for pilots. **TOPIC:** Previously, monovision was touted as a viable solution to age-related visual changes, with one eye corrected for distance vision and the other eye corrected for near vision. This was accomplished with contact lenses, LASIK/PRK, or IOLs. Monovision has significant disadvantages, including compromised vision at near, far and intermediate distances, poor depth perception, and diminished peripheral field of vision. Furthermore, when aviators with monovision correction eventually develop cataracts, decreased vision in the eye being utilized for flying diminishes even further, while the eye being utilized for near vision also has reduced acuity and fatigues more readily. Binocular vision is tremendously helpful to pilots during the final approach and landing. Pilots utilizing monovision tend to have steeper approaches, higher sink rates at touchdown, and are less accurate with touchdown location. Numerous studies continue to report that suboptimal ophthalmic correction in pilots has contributed to a number of aviation accidents and incidents. Novel trifocal lens implants focus light from distance, intermediate, and near simultaneously - addressing all focal lengths in a patient's field of view. With intermediate-distance vision optimized to 60 cm focal point, and near vision optimized to 40 cm focal point, the lens enables 88% of light utilization with approximately 50% dedicated to distance, 25% to intermediate, and 25% to near vision. Patients can have outstanding visual acuity, even in low-light environments.

APPLICATION: Trifocal IOLs are rapidly becoming the treatment of choice for age-related visual changes in patients with incredible visual demands, such as aviators. The enhanced visual parameters of these new lenses are critical for pilots when performing tasks such as aerial refueling, formation flying, and landing on a carrier deck.

Learning Objectives

1. The audience will learn about novel, trifocal intraocular lens implants (IOLs) and the benefits they offer over traditional treatment options for age-related visual changes.
2. The audience will learn the pitfalls of monovision correction and its impact on the occupational performance of aviators.

[267] THE IMPACT OF MRI IN IDENTIFICATION OF RADICULAR ODONTOGENIC CYSTS

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(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: Radicular cysts are the most common odontogenic cystic lesions arising from inflammatory pulp. Being developed at root apices of involved teeth, they tend to enlarge and infect not only bone and neighboring teeth, but also the maxillary cavity, usually being

detected or verified by radiological assessment. **BACKGROUND:** In rare cases, symptoms can be so severe that those affected endanger their flight safety due to painful misconduct. For example, in a survey of 1,184 military and civilian aviators in France, 10 out of 74 reported cases of barodontalgia were considered to be so severe that they impaired flight safety (Stoetzer M et al. Pathophysiology of barodontalgia. Case Rep Dent. 2012; 2012:453415). **CASE DESCRIPTION:** We report a well-documented case of a radicular odontogenic cyst affecting an upper molar in a 41-year-old flight surgeon. Symptoms with presence of intermittent dull pain were first determined two years after root filling. In spite of dental X-ray, the issue had not been clarified for ten years until the use of a pressure chamber leading into throbbing pain. Diagnosis was then made by magnetic resonance imaging (MRI) and confirmed by digital volume tomography. The attempt of root filling's revision resulted in flaring up of the cyst, causing massive pain, visual impairment alongside a swollen face as well as the urge of immediate surgery. Following extraction of infected tooth and cleaning of maxillary cavity, the patient had no longer complaints and continued to fly as a flight surgeon. **DISCUSSION:** Our case documents that in the aviation dentistry environment, radicular odontogenic cysts may cause unfit assessment which can be detected by MRI and be resolved by surgical means. Furthermore, it points out the value of MRI versus X-ray imaging.

Learning Objectives

1. Participants will be able to respond to patients facing toothache.
2. The audience will be able to understand the necessity of MRI.

[268] JAXA FLIGHT SURGEON TRAINING PROGRAM OVERVIEW FOR LAST OVER 20 YEARS

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¹Japan Aerospace Exploration Agency, Tsukuba-shi, Japan

(Education - Program / Process Review Proposal)

BACKGROUND: Japan Aerospace Exploration Agency (JAXA) has been training more than fifteen physicians for over 20 years and they become JAXA Flight Surgeons (J-FSs). J-FSs were trained and went through their medical operations under Space Shuttle program as well as International Space Station (ISS) program. Early J-FS training program relied on US Aerospace medicine residency program and it had not changed for years. As JAXA astronauts were assigned to long duration mission in ISS since 2009, JAXA reconsidered about J-FS training.

OVERVIEW: Period 1(P1): 1985~2013. As Aerospace medicine residency program did not exist in Japan, physicians who have acquired specialized field such as Cardiology, Psychiatry, etc., were preferable as a prerequisite for medical practice in JAXA. The Core of the training program at that period was to complete 2 years of Aerospace medicine residency program at Wright State University in Ohio. JAXA physicians also acquired certified Occupational medicine physician in Japan. After these processes, they became accredited J-FSs. Period 2(P2): 2014~. 4 training programs were integrated into one year of training, including both domestic and international training. Basically, the promise of being a specialist and certified Occupational medicine physician is unchanged. 1) UTMB Principles of Aviation and Space Medicine (PASM), 2) FAA Aviation Medical Examiners seminar basic course, 3) Mayo Aerospace medicine training course, 4) NASA ISS program eLearning course & NASA Flight Surgeon classroom. All J-FSs that have completed the P2 training program are certified in Multilateral Space Medicine Board under ISS program. **DISCUSSION:** One of significant differences between P1 and P2 was the basic training period to J-FS. P1 took more than 2 years because it required domestic training prior to two-year US residency program, but P2 ended in 1 year, including on-site training at NASA Johnson Space Center (JSC). UTMB PASM is four-week course, but it is very dense content and consists of various international participants every year. Although the training period has been shortened, the depth of content may have increased due to repeated learning opportunities in FAA and Mayo in various ways after UTMB PASM. In addition, medical operations of JAXA astronauts carried out almost annually since 2009, so it was possible to shadow assigned J-FS in JSC for several months during training programs.

Learning Objective

1. Understand the history of JAXA Flight Surgeon training program from Space Shuttle era to International Space Station era and the scope of International Space Exploration era.

[269] A RETROSPECTIVE ANALYSIS OF THE LONGITUDINAL CHANGES IN THE BODY MASS INDEX OF BRITISH ARMY PILOTS

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⁶Headquarters, Army Air Corps, Middle Wallop, United Kingdom

(Original Research)

INTRODUCTION: Components of military and civilian aircraft are manufactured according to design parameters that account for the physical characteristics of the occupant(s). In light of emerging patterns in the general population, we sought to examine the longitudinal trends of Body Mass Index among Army pilots. Although data related to individual changes in BMI with age are available in the peer-reviewed medical literature, the generalizability of this data to military populations could be challenging. **METHODS:** Written informed consent was obtained from 106 participants to extract height and weight data from their electronic medical record within the Defence Medical Information Capability Programme (DMICP). The enrolled study population was entirely male, with a mean age of 33.4 years (SD 6.4). Apache (n=72), Wildcat (n=14), and Gazelle (n=10) pilots composed the majority of the sampled population. The mean length of service was 8.6 years (SD 4.7 years). Height and weight data from aircrew medical screening encounters was entered into a de-identified data base, and paired T-tests were used to compare "initial" and "final" data points. Regression analysis was used to explore the relationship between an individual's length of service compared to their change in BMI. **RESULTS:** The mean change in weight for the enrolled population was 4.6 kg (SD 7.3 kg). The mean change in height was 0.6 cm (SD 1.9 cm). The mean change in BMI was 1.3 kg/m² (SD 2.4 kg/m²). Regression analysis on the collected data suggests that the change of BMI is equal to 1.62 times the number of years served as a pilot. However, this regression analysis only accounts for 21.3% of the variability between the two variables (as defined by the resultant R2 value). **DISCUSSION:** The results of this study should be used to inform future policy formulation related to the body composition of Army aviation applicants, the retention of previously qualified personnel, and acquisition programs that require insights associated with the anthropometry of pilots.

Learning Objective

1. Understand the potential changes in anthropometry associated with aging.

[270] CHALLENGES IN AEROSPACE MEDICINE FOR IBERO-AMERICA: THE COLOMBIAN EXPERIENCE

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(Education - Tutorial Proposal)

BACKGROUND: The aerospace medicine scientific community in Ibero-America share history, culture and language, as well as experience and knowledge. Many professionals from diverse Iberoamerican countries have generated important contribution to the global workforce and scientific knowledge in aerospace medicine, understanding that it is an essential area for effective and safety flight operations. Colombia is an example of the development achieved in these countries and highlights the importance of integrating work and cooperation among countries in order to reach common goals and objectives. **OVERVIEW:** The aerospace medicine in Colombia have had an important growth over the last twenty years related to two main aspects: the establishment of a highly specialized program in operational health for the Colombian Air Force, which has become a

national and regional reference, and the creation of an Aerospace Medicine Residency Program provided and certified by the National University of Colombia in alliance with prestigious national and international civilian and military institutions, optimizing requirements of formal education in aerospace medicine to the countries of the region. The lecture gives insight into how these projects were achieved, the main challenges faced, lessons learned and successful results. **DISCUSSION:** The lecture will discuss about the significance of creating integral aerospace medicine programs support by formal education, and the strategic importance of inter-institutional partnership, cross-disciplinary research and transversal work lines. Also, the lecture will identify the main challenges facing Iberoamerican countries in order to the continued improvement in aerospace medicine that contributes to the global aeronautical community.

Learning Objectives

1. The participant will be able to discuss about the importance of establishing an integral aerospace medicine program.
2. The participant will be able to discuss the main challenges to continued improvement in aerospace medicine.
3. The participant will be able to discuss the importance of inter-institutional alliances and cooperation among countries.

[271] SELECTION OF AIR TRAFFIC CONTROLLER TRAINEES

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(Original Research)

INTRODUCTION: The 2-year training period for air traffic controllers puts a heavy financial burden on the training organization and means a continuous high workload to the ATCO-trainees. Even bigger problem is the high percentage of drop-outs during the training, which raises costs. To select the best candidates – thus reducing the number of drop-outs - we have been involved in the multistage selection process of the Hungarian ANSP, HungaroControl. **METHOD:** monitoring and evaluating certain physiological parameters can contribute to a better assessment of an individual. The candidates, after FEAST 2 test came to our center for a sleep assessment, a standard aeromedical examination, anthropometry, 6-min physiological measurement, dry electrode EEG and cognitive function test. During a 6 min interval we evaluate the candidates' physiologic state in a resting position. We use HRV (heart rate variability), which gives information of the autonomic nervous system, the electric and the mechanical state of the heart, and the possible inflammations. Arteriography demonstrates the characteristics of large arteries and the endothelial function. It reveals several parameters: augmentation index (AIX) traces the degree of pulse wave reflection, state of peripheral circulation, and is related with cardiovascular mortality. Pulse wave velocity (PWV) represents the speed of the pressure wave on the aorta generated by the heart's contraction, which is crucially affected by the elasticity of the aorta. PWVao is a solid, independent, proven risk factor of cardiovascular mortality. Diastolic area index (DAI) represents the diastolic proportion of the cardiac cycle, gives information on the pressure properties of the left coronary artery. With dry electrode EEG we monitor the well-known brain wave range combinations. During the sleep assessment by using a special device we get valuable information about the examinees sleeping habits, heart rate, breath frequency, deep sleep time, apnea time, sleep efficiency. **RESULTS:** We evaluated the findings of the 85 candidates and presented a detailed report of all the candidates. Based on our report a „ranking" was made, and it was an important data for HungaroControl in the recruitment decision. **DISCUSSION:** At the moment we are waiting the feedback from HungaroControl about the trainees who were recruited based upon our ranking, to see how they met the training requirements and whether the rate of drop-out could be reduced.

Learning Objective

1. The importance of screening physiological status will be highlighted.

Wednesday, 05/20/2020
Centennial I

10:30 AM

[S-54]: PANEL: HYPOXIC PULMONARY VASOCONSTRICTION REFLEX: AEROMEDICAL IMPLICATIONS

Chair: Gregg Bendrick

Co-Chair: Charles Mathers

PANEL OVERVIEW: The Hypoxic Pulmonary Vasoconstriction (HPV) reflex is a condition in which pulmonary arterioles constrict (thereby reducing blood flow) in response to decreased levels of alveolar oxygen. Upon exposure to hypoxia, as can occur during flight at higher altitudes, the HPV reflex increases pulmonary vascular resistance (PVR). This Panel will examine some cardiac conditions in which the HPV reflex is of concern, the current data and testing for passengers and/or pilots with pulmonary hypertension, as well as the technical challenges of assessing RV function using echocardiography. Specifically, after a short review of the background and physiology of the Hypoxic Pulmonary Vasoconstrictive reflex, the Panel will feature Dr. Thomas Smith, from the United Kingdom, who will discuss studies investigating hypoxic pulmonary vasoconstriction during actual and simulated commercial airline flights. Then Dr. Leigh Seccombe, from the University of Sydney, who will be discussing effects of hypoxia experienced during commercial air travel on patients with pre-existing cardiopulmonary disease. After that Dr. Matthew Cooper, an FAA Consultant from the USA, will discuss concerns regarding congenital heart disease (e.g. hypoplastic right ventricle)—with or without surgical correction. Finally, the team of Dr's. Kamine & Formanek (Surgeon and Anesthesiologist, respectively, from the USA) will discuss the echocardiographic evaluation of the right heart in passengers and airmen, to include some of the technical challenges associated with echocardiographic assessment.

[272] HYPOXIC PULMONARY VASOCONSTRICTION: GENERAL BACKGROUND AND PHYSIOLOGY

Gregg Bendrick¹

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(Education - Program / Process Review Proposal)

BACKGROUND: Hypoxic Pulmonary Vasoconstriction (HPV) is a reflex contraction of the pulmonary arterial smooth muscle cells in response to a decreased partial pressure of alveolar oxygen (PAO₂). It was first identified in 1894 by Bradford & Dean, and was later described in more detail in 1946 by von Euler & Liljestrand. Since then the HPV reflex has been elucidated in even more detail. **OVERVIEW:** The minimal PAO₂ for HPV to occur is 86 mmHg. There is a half-maximal response at 57 mmHg, and a maximal response at 36 mmHg. (Of note, at 8000 feet—the maximum allowable cabin altitude for commercial airliners—the PAO₂ = 69 mm Hg). With regard to timing of onset, HPV has two distinct phases. In moderate hypoxia (i.e. PAO₂ = 30 - 50 mmHg) Phase 1 begins within a few seconds and reaches a plateau at 15 - 30 minutes. Phase 2 begins after 30 - 60 minutes and achieves its maximum level at about two hours. Sensitization also appears to occur, where a second hypoxic exposure will result in a greater response than the first. Also, when a normal PAO₂ is once again restored, the PVR does not immediately return to normal; return to normal may in fact take several hours. Certain medications attenuate the HPV reflex. These include phosphodiesterase inhibitors (e.g. sildenafil), calcium channel blockers (e.g. diltiazem, verapamil, nifedipine), angiotension-converting enzyme (ACE) inhibitors, angiotension II receptor blockers, steroids, acetazolamide, nitroglycerin and nitroprusside. **DISCUSSION:** Although there has been some discussion of HPV in the etiology of such things as High Altitude Pulmonary Edema (HAPE), the importance of HPV in commercial air travel, for both pilots and passengers, has been appreciated only more recently. There are certain conditions in which an increase in PVR could have serious consequences during air travel. These include Pulmonary Hypertension, right-sided heart failure, or congenital heart disease such as hypoplastic right ventricle (with or without surgical correction). Properly evaluating such individuals with

regard to either passenger travel or pilot selection can be challenging, and will sometimes require a more focused assessment.

Learning Objective

- To understand the physiologic action of the Hypoxic Pulmonary Vasoconstriction reflex, to know the levels of hypoxia at which this reflex occurs, to know the onset and duration of the effect, and to know at least three medications that can decrease this reflex.

[273] HYPOXIC PULMONARY VASOCONSTRICTION DURING AIR TRAVEL

Thomas Smith¹

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(Education - Program / Process Review Proposal)

BACKGROUND: Until quite recently it was unknown whether the mild hypoxia experienced during air travel was sufficient to trigger hypoxic pulmonary vasoconstriction. Such a response could cause a potentially dangerous increase in pulmonary artery pressure in-flight, but guidelines regarding fitness-to-fly for passengers with relevant medical conditions, such as pulmonary arterial hypertension, were based on extrapolation from animal experiments. Several years ago we embarked on a series of studies investigating the pulmonary vascular response to air travel during commercial airline flights and in a hypobaric chamber.

OVERVIEW: Healthy volunteers were studied using in-flight echocardiography on a London-Denver flight, during which systolic pulmonary artery pressure (SPAP) was found to increase by approximately 20%. A patient with Chuvash polycythemia, a rare genetic condition that causes increased hypoxic pulmonary vasoreactivity, was studied throughout a London-Dubai flight, during which SPAP rapidly increased into the pulmonary hypertensive range. During simulated commercial airline flights in a hypobaric chamber, SPAP increased more in older participants (> 60 years) than in younger participants (< 25 years). **DISCUSSION:** Pulmonary artery pressure increases during air travel in healthy passengers, and in a susceptible individual this response can result in flight-induced pulmonary hypertension. This response is greater in older people. Although clinically inconsequential for most people, hypoxic pulmonary vasoconstriction during air travel can harm vulnerable passengers by provoking or exacerbating in-flight cardiopulmonary emergencies. An extended hypoxic challenge test with simultaneous echocardiography may be particularly informative in assessing the likelihood of such adverse sequelae.

Learning Objective

- To gain greater understanding of the physiological effects of routine aircraft cabin hypoxia, in particular the pulmonary vascular response.

[274] ECHOCARDIOGRAPHIC EVALUATION OF THE RIGHT HEART IN PASSENGERS AND AIRMEN

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(Education - Program / Process Review Proposal)

BACKGROUND: Transthoracic echocardiography (TTE) can be a useful screening tool for passengers or airmen with baseline pulmonary hypertension or congenital heart disease in which hypoxic vasoconstriction associated with altitude can precipitate right heart failure. **OVERVIEW:** Tetralogy of Fallot is the most common cyanotic congenital heart defect, although most of these patients are repaired early in life but may have downstream consequences. Primary pulmonary arterial hypertension is another rare cause of right heart disease in young patients. However, the most common causes of right heart failure are left heart failure and lung disease. The right side is a low-pressure system and may be acutely pressure and volume overloaded. Chronic hypoxemia causes pulmonary vasoconstriction with ensuing RV enlargement and hypertrophy, but RV function is typically relatively spared. However, worsening hypoxemia or hypercarbia with may acutely cause right pressure overload. **DISCUSSION:** The use of TTE to evaluate the RV is more difficult than the evaluation of the left ventricle (LV) because of the complex geometry of the RV, and complete exams are often unable to be obtained even by experienced sonographers. Assessment of RV function consists of assessment of ventricular pressure, volume, and contractility. Right ventricular systolic pressure (RVSP) is typically used as a surrogate for pulmonary artery (PA)

and requires tricuspid regurgitation and accurate estimation of CVP. Low tricuspid valve annular plane excursion (TAPSE) is indicative of reduced contractility. Accurate assessment of the RV will be necessary in an increasingly diverse patient population for atmospheric and spaceflight.

Learning Objective

1. Understand the various ways of assessing Right Ventricular function on transthoracic ultrasound.

[275] EFFECTS OF HYPOBARIC HYPOXIA EXPERIENCED DURING COMMERCIAL AIR TRAVEL ON PATIENTS WITH PRE-EXISTING CARDIOPULMONARY DISEASE

Leigh Michelle Seccombe¹

¹University of Sydney, Sydney, Australia

(Education - Program / Process Review Proposal)

BACKGROUND: The effect of hypobaric hypoxia experienced during commercial aircraft travel on patients with pre-existing cardiopulmonary disease was investigated. Disease groups included chronic obstructive pulmonary disease, idiopathic pulmonary fibrosis, pulmonary arterial hypertension and Parkinson disease. Comparisons were made to the healthy normal response both at rest and under mild exertion. Investigations using laboratory simulations and onboard commercial flights have included arterial blood gas, ventilatory and hemodynamic response using echocardiography. **OVERVIEW:** These investigations confirmed that at barometric pressure equivalent to 8000ft altitude, patients with stable cardiopulmonary disease experience significant hypoxemia that is well tolerated while inactive. However, exercise intolerance with significant dyspnea is common. Patients with primary pulmonary hypertension experience further significant increases in pulmonary pressure, but right heart function is preserved. This suggests that there is no additional adverse contribution from hypoxic pulmonary vasoconstriction at this level or duration of hypoxia. The risk of cardiac decompensation is increased in the presence of co-morbidity, with the potential failure to maintain required oxygen delivery on mild exertion. **DISCUSSION:** Whilst reported adverse medical events are infrequent, there is a paucity of epidemiological data on travel risk. Laboratory simulation tests accurately predict oxygenation at 8000ft altitude; however further research is needed to determine its utility in the assessment of suitability for commercial air travel in those at risk.

Learning Objective

1. To understand the physiological considerations relevant to commercial aircraft travel in patients with pulmonary and/or cardiac disease.

[276] HYPOXIC PULMONARY VASOCONSTRICTION AND CONGENITAL HEART DISEASE

Matthew Cooper¹

¹3M Health Care Business Group, St. Paul, MN, USA

(Education - Program / Process Review Proposal)

BACKGROUND: Improved surgical outcomes following the correction of complex congenital heart disease have resulted in long-term survival and near normal life expectancy. This has impacted the population as a whole and the pool of pilot candidates and pilots. **OVERVIEW:** A particular subset of these individuals has single ventricle or so-called 1-1/2 ventricle physiology in which all or a component of pulmonary blood flow, respectively, is passive. Such "Fontan" pulmonary blood flow is determined in part by pulmonary vascular resistance. Some reactivity of the pulmonary bed is anticipated in response to the relative hypoxia at higher altitudes, even during pressurized commercial flight. This suggests that evaluation of oxygen saturation at rest and with exercise are important, and that it may be appropriate to consider testing the pulmonary response to altitude induced hypoxia to determine whether a specific requirement for supplemental oxygen is required based on physiology. **DISCUSSION:** The character and incidence of anatomic substrates corrected to passive pulmonary blood flow will be reviewed, as will theoretical vs. real implications for pilot evaluation and performance. The latter may include consideration of the special issuance class of medical that satisfies an individual's flying aspirations.

Learning Objective

1. To understand the implications of congenital heart disease on medical qualification for flight as either a pilot or a passenger, in the context of hypoxic pulmonary vasoconstriction.

Wednesday, 05/20/2020

10:30 AM

Centennial II

[S-55]: PANEL: OPTIMIZING HUMAN PERFORMANCE VIA NEUROMODULATION AND PERSONALIZED HEALTH

Chair: Lindsey McIntire

PANEL OVERVIEW: This panel will discuss the efforts of researchers at the Air Force Research Laboratory (AFRL) to optimize human performance through neuromodulation and personalized health monitoring. AFRL has previously found that non-invasive neuromodulation is capable of increasing arousal, accelerating learning, and mitigating fatigue due to sleep loss by using a form of electrical stimulation on the head called transcranial direct current stimulation (tDCS). This panel will showcase some of the mechanisms of action causing these behavioral changes through human fMRI data and rodent models. Additionally, AFRL has recently been investigating the effects of other forms of neuromodulation at optimizing performance. One of those technologies is called cervical transcutaneous vagal nerve stimulation (tvNS). Our panel will discuss how tvNS has been found to accelerate learning in the laboratory and with field testing on image analyst trainees. Another neuromodulation technique this panel will discuss is called photobiomodulation (PBM). Recently, AFRL has been investigating the effects of PBM on working memory. Finally, optimizing performance through personalized health monitoring is also important for warfighter performance. This panel will discuss how biomarkers of stress are being used to predict performance and influence mission planning.

[277] EFFECTS OF TRANSCUTANEOUS VAGAL NERVE STIMULATION ON LEARNING FOR IMAGE ANALYSTS

Lindsey McIntire¹, R. Andy McKinley², Chuck Goodyear¹

¹Infoscitex, Inc., Dayton, OH, USA; ²Air Force Research Laboratory, Dayton, OH, USA

(Original Research)

INTRODUCTION: The demand for image analysts has grown exponentially over the past decade. This has caused an unsustainable manpower issue and high attrition rate due to burnout. Therefore, investigating a way to get more analysts into the field faster is of interest to the Air Force. A form of non-invasive neuromodulation called transcutaneous vagal nerve stimulation (tvNS) stimulates the vagus nerve in the neck which is directly connected to a part of the brain called the locus coeruleus (LC). The LC is responsible for attention, arousal, and memory formation/retention. Therefore, we hypothesize that by activating the vagus nerve with tvNS we can enhance memory formation/retention for image analysis in both a laboratory and field setting. **METHODS:** Twenty active duty Air Force members participated in each group of both the laboratory and field experiment. Both experiments had two groups: sham tvNS and active 25Hz tvNS. In the laboratory experiment, participants received stimulation before and in the middle of training on a static-image object recognition task using synthetic aperture radar images for 4 consecutive days with follow-up testing at 1-day, 30-days, and 90-days. In the field experiment, full-motion video (FMV) analysis trainees were given stimulation before class (approximately 0700) for 4 consecutive days. **RESULTS:** For the laboratory experiment, the results showed a significant improvement in accuracy by Day 2 of training for the active tvNS group compared to sham stimulation that continued for the duration of the experiment. For the field experiment, active tvNS has improved FMV performance on the first day of stimulation. Further, participants in the active tvNS group reported feeling less distressed, more able, and had a general overall improved mood rating compared to sham on all stimulation days. **DISCUSSION:** These results provide evidence that tvNS enhances learning in both laboratory experiments and with actual trainees. These results also show that tvNS enhances performance in simple and complex object-recognition tasks. More research is needed to determine optimal timing of stimulation and what other applications this tool could be useful for.

Learning Objectives

1. Understand the effects of tVNS on image analyst training.
2. Understand the effects of tVNS on mood.

[278] THE EFFECTS OF TRANSCRANIAL DIRECT CURRENT STIMULATION (tDCS) ON THE BRAIN USING FUNCTIONAL MAGNETIC RESONANCE IMAGING

Richard McKinley¹, Lindsey McIntire², Chuck Goodyear²
¹Air Force Research Laboratory, Dayton, OH, USA; ²Infoscitex, Dayton, OH, USA

(Original Research)

INTRODUCTION: Over the past decade our lab and several others have found improvements in cognitive performance in healthy subject populations when using a form of non-invasive neuromodulation called transcranial direct current stimulation (tDCS). However, little is known about the mechanisms of action the lead to improved attention, learning, memory, and arousal. This study examined the effects of tDCS on the brain using functional magnetic resonance imaging (fMRI). **METHODS:** Sixty subjects were randomly assigned to either 2mA tDCS stimulation, 1mA tDCS stimulation, or sham stimulation (n=20 in each group). Subjects came in for 3 consecutive days of testing with stimulation followed by a 1 week and 2 week follow-up testing with no stimulation. On each testing day participants did baseline scans which consisted of fMRI, arterial spin labeling (ASL), magnetic resonance spectroscopy (MRS), and diffusion tensor imaging (DTI). Participants then underwent 30-minutes of tDCS according to their assigned condition while doing a sustained-attention task. At the conclusion of stimulation, participants were immediately placed back in the scanner and repeated the same scans. **RESULTS:** Our results show greater differences in active stimulation over sham in a part of the brain called the locus coeruleus (LC). The LC is the primary norepinephrine nucleus for the brain and is believed to be responsible for attention, arousal, wakefulness, and memory formation/retention. **DISCUSSION:** Activation of the LC helps explain behavioral results over the past decade that show tDCS can accelerate learning, mitigate fatigue, increase arousal, and improve attention. However, because the LC is a deep brain structure it is likely that current is not passing directly that deep into the brain but reaching the LC through peripheral nerves such as the trigeminal nerve. Future research should focus on stimulating peripheral nerves that are directly connected to the LC such as the trigeminal and vagus nerves.

Learning Objective

1. The effects of transcranial direct current stimulation on functional brain activity and cognitive performance.

[279] STRESS RELATED BIOMARKERS: PERFORMANCE PREDICTION AND ASSESSMENT OF STRESS EXPOSURE TRAINING IN A PREPARATORY COURSE FOR SPECIAL WARFARE TRAINEES

Laura Olsen¹, Charles Goodyear¹, Candice Hatcher-Solis¹, Regina Shia¹

¹Air Force Research Lab, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Previously, Battlefield Airmen (BA; now known as Special Warfare) initial training courses experienced very high rates of attrition¹. High attrition rates increase training and recruitment costs². To improve attrition rates for the courses of initial entry (CoIE), a BA Preparatory course was designed for the purpose of exposing trainees to stressful situations that they will endure throughout the pipeline. Biomarkers can assist in predicting attrition and informing proper preparatory training³. This study investigated stress related plasma biomarker levels in trainees in response to stress event exposure during the BA prep course. **METHODS:** 33 soldiers whom enrolled in a BA prep course participated in this study. As part of their normal training, BA were exposed to minor stress (standard physical training) and 2 extensive training days (ETDs) lasting ~22 hours. Blood plasma and questionnaire data were collected at baseline and after minor/extensive stress events. ELISA analysis of plasma was conducted for 7 biomarkers. Selection outcomes for the following CoIE were also recorded. **RESULTS:** Compared to baseline (BL) levels, cortisol, neuropeptide Y (NPY), and testosterone

(p < 0.01) were increased after exposure to a minor stress event. After ETDs, cortisol, dehydroepiandrosterone sulfate (DHEAS), noradrenaline (NE), NPY, and orexin levels (p < 0.01) were increased compared to BL. DHEAS and NPY increases in response to stress exposure were differentially expressed between those who successfully completed their following CoIE and those who did not. Multiple logistic regression modeling revealed increases in DHEAS and NPY/NE in response to the first minor stress event exposure to increase the likelihood of BA successfully completing their CoIE. **DISCUSSION:** Minor and ETD stress events produced different biomarker profiles in BA during their prep course. Although further validation studies are required, stress related biomarkers (DHEAS, NPY, and NE) may be useful for predicting a warfighter's resilience to stress, susceptibility to attrition, and the effectiveness of stress exposure training for an individual. **REFERENCES:** 1. Nishikawa, et al., 2010. *Medical Attrition of Battlefield Airmen Trainees*. 2. Manacapilli, et al., 2012. *Reducing attrition in selected Air Force training pipelines*. 3. Wolf, et al., 2016. *Serotonin as a Biomarker: Stress Resilience among Battlefield Airmen Trainees* (No. AFRL-SA-WP-SR-2016-0004).

Learning Objective

1. To determine stress biomarker profiles during stress exposure training throughout a BA preparatory course and investigate the potential utilization of these biomarkers for predicting success in the subsequent CoIE.

[280] PHOTOBIMODULATION AND COGNITIVE PERFORMANCE

Nathaniel Bridges¹, Onyekachi Udeinya², Bethany Repp³

¹Air Force Research Laboratory, Wright-Patterson AFB, OH, USA;

²Infoscitex, Dayton, USA; ³Perduco Group, Dayton, OH, USA

(Original Research)

INTRODUCTION: Research suggests that laser-based transcranial photobiomodulation (PBM), which emits red/infrared light into the brain, can improve cognitive performance—especially when administered repeatedly. It is unclear, however, whether PBM using light emitting diodes (LEDs), which would be easier to operationalize, cause similar cognitive effects in DoD-relevant populations. Further, it is unclear whether a single-session of LED-based PBM is sufficient to affect cognitive performance. Researchers have associated alpha and gamma oscillations with attention and WM performance, and recently showed that a single session of LED-based PBM pulsed in the gamma frequency range (g-PBM) can alter these frequency bands. As such, we hypothesized that a single session of LED-based g-PBM would be sufficient to impact performance in an attention and WM-based task. **METHODS:** To address the above, we administered a single session of 20-minute LED-based g-PBM in 40 male and female military and civilian participants. One-half of the participants received real PBM, while the other half received a placebo form. We administered a 30-minute WM task, which contained a spatial and temporal WM component, immediately before, during, and after g-PBM. We gave the attention-based task immediately before and after the start and end of the WM-task. Lastly, subjects filled out a 7-point scale mood questionnaire before and after the attention-based task. The Air Force Internal Review Board approved the procedures used in this study. We used a combination of ANOVA and t-tests for statistical analyses. **RESULTS:** Active but not placebo g-PBM differentially affected spatial and temporal WM performance when compared to baseline performance. In contrast, active g-PBM did not affect attention performance as hypothesized. We also found a differential impact on subjective measures of mood from the mood questionnaire when comparing the real and placebo g-PBM conditions. **DISCUSSION:** These results suggest that a single session of PBM is sufficient to impact WM performance, but does not support our hypothesis concerning PBM effects on attention performance. Given that we administered the attention task after the WM task, it is possible that the effects of PBM were short-lived, and did not extend beyond the duration of the WM-task. More research is required to parse out these potential time course effects.

Learning Objectives

1. Understand what is meant by "photobiomodulation".
2. Understand what research has been done using photobiomodulation on cognitive performance.
3. Understand what future research is needed to advance photobiomodulation research for the Department of Defense.

[281] NON-INVASIVE BRAIN STIMULATION AFFECTS RAT HIPPOCAMPAL PROTEIN EXPRESSION IN A POLARITY AND INTENSITY-DEPENDENT MANNER

Candice Hatcher-Solis¹, Seung Ho Jung¹, Sean Harshman¹, Jennifer Martin¹, Ryan Jankord²
¹Air Force Research Labs, Dayton, OH, USA; ²Adyptation, Dayton, USA

(Original Research)

INTRODUCTION: Transcranial direct current stimulation (tDCS) is the application of low intensity current through non-invasive electrodes placed on the head that target specific areas of the brain. Prevailing evidence indicates tDCS affects learning and memory in a polarity and intensity-dependent manner, but the regulatory mechanisms remain unclear. Here, we examined the impact of tDCS polarity and intensity on protein expression in the rat hippocampus. We hypothesized anodal tDCS would significantly upregulate hippocampal proteins associated with learning and memory in an intensity-dependent manner and that cathodal tDCS would have opposing effects. **METHODS:** tDCS was applied to 25 adult, male Sprague Dawley rats randomly assigned to 5 treatment groups receiving sham, anodal 250 μ A (A250), anodal 500 μ A (A500), cathodal 250 μ A (C250), or cathodal 500 μ A (C500) tDCS (n=5/group). Animals were euthanized 2 hours post-stimulation and hippocampal tissue was collected. Individual protein abundances from hippocampal synaptoneurosomes were quantified using bottom up liquid chromatography mass spectrometry analysis by researchers blinded to the treatments. Network science was utilized to evaluate the protein network differences between the groups. **RESULTS:** Ingenuity pathway analysis created merged networks for the comparisons between tDCS and sham stimulation. For A250 vs. sham, protein networks associated with learning (# of nodes = 10 & p = 0.00167) and cognition (# of nodes = 11 & p = 0.000832) were identified. For A500 vs. sham, protein networks associated with cognition (# of nodes = 28 & p = 2.15E-13), learning (# of nodes = 27 & p = 3.35E-13), spatial learning (# of nodes = 14 & p = 1.38E-10) and memory were detected. For C250 vs. sham, protein networks associated with cognition (# of nodes = 9 & p = 0.000262), learning (# of nodes = 8 & p = 0.000939), and associative learning (# of nodes = 2 & p = 0.00611) were identified. For C500 vs. sham, learning (# of nodes = 4 & p = 0.00664) was the only cognition-associated function detected from the merged network. **DISCUSSION:** Our data provide evidence that tDCS modifies hippocampal protein networks in a polarity and intensity-dependent manner with A500 tDCS affecting more protein networks associated with cognition. This work has identified multiple candidate protein targets and regulatory pathways for the effects of tDCS on learning and memory.

Learning Objectives

1. The participant will be able to understand how transcranial direct current stimulation affects rat hippocampal protein expression in a manner that may promote learning and memory.
2. The participant will be able to understand how different parameters of transcranial direct current stimulation may affect rat hippocampal protein expression.

Wednesday, 05/20/2020
 Centennial III

10:30 AM

[S-56]: PANEL: EMERGENCY, CRITICAL AND PERIPROCEDURAL CARE DURING LONG SPACE MISSIONS: STATE OF THE ART

Sponsored by the European Society of Aerospace Medicine

Chair: Jochen Hinkelbein

Co-Chair: Keith Ruskin

PANEL OVERVIEW: This session is sponsored by NASA, DGLRM, and ESAM. It presents five different topics related to emergency, critical and periprocedural care during long space missions. The presentations describe the state of the art in the specific fields.

[282] SURGICAL IMPLICATIONS OF MICROGRAVITY

Mansoor Khan¹

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(Education - Program / Process Review Proposal)

BACKGROUND: Advances in surgical care and the capability of remote surgery have led to increasing the scope of deployments, particularly when surgical care cannot be provided due to absent evacuation chain. The remotest location known, without argument is the expanse of space. Thus, comes the question, can we provide surgical intervention in microgravity, and if so, what are the implications? The three main factors to consider are surgeon related, patient related, and equipment related, which we will explore in greater depth in this presentation. **OVERVIEW:** The simplest problems are the ones that are most likely overlooked, leading to subsequent complications. Surgeon related factors, in microgravity include opposing forces, maintaining stability whilst operating, amongst many others. Patient related concerns are numerous and focus on contamination, physiological and anatomical changes specific to this environment. The equipment utilized in the terrestrial environment may not be suitable in microgravity and this will be discussed during the presentation. **DISCUSSION:** Surgical intervention, although feasible in microgravity, potentially will require numerous developmental interventions. It has been demonstrated that on terrestrial environments, austere surgery is more difficult than conventional locations, with surgery in space being a different magnitude of difficulty.

Learning Objectives

1. Understand surgeon-related implications of performing operations in microgravity.
2. Understand patient-related physiological and anatomical implications of microgravity.
3. Understand constraints of equipment in microgravity.

[283] EXPERIENCE WITH SURGERY IN SPACE

Jay Buckley¹, Jennifer Fleischer²

¹Geisel School of Medicine at Dartmouth, Lebanon, NH, USA; ²Duke University, Durham, NC, USA

(Education - Program / Process Review Proposal)

BACKGROUND: As space mission duration increases, the likelihood that surgical intervention will be needed increases as well. The Neurolab, Spacelab Life Sciences 2, and Spacelab Life Sciences 1 Space Shuttle missions included several demanding dissections and surgical procedures using rodents. These missions were dedicated life sciences missions with various human and animal experiments. Experiments included work with equipment (medical restraint tables, IV pumps, etc.) and the performance of intensive animal dissection and surgical procedures. This presentation will review what took place on these missions and the lessons these experiences offer for the future. **OVERVIEW:** The procedures that were performed included: tail vein cannulation, timed dissection of temporal bone, timed laminectomy, various dissection procedures, perfusion fixation, and survival surgery (anesthesia, visualization of soleus in neonatal rat, injection with tracer, wound closure, recovery). Most procedures were performed in a workstation/glovebox that prevented fluids and fixatives from reaching the spacecraft cabin. Subjectively, crewmembers reported slight reductions in dexterity early in flight, which improved over the course of the mission. The main issues were developing appropriate restraints for the crewmembers and the surgical tools. **DISCUSSION:** Surgical techniques successfully demonstrated in rats during space flight included general anesthesia, wound closure, wound healing, hemostasis, control of surgical fluids, operator restraint, and control of surgical instruments. Delicate surgical procedures were performed successfully (the first survival surgery was done on Neurolab). ACLS protocols and procedures were also developed and tested. With proper planning and training, surgical procedures could be accomplished on longer duration missions and planetary surfaces.

Learning Objectives

1. Learn about previous experience with surgery in space.
2. Learn about other complex medical/research procedures done in space.
3. Review issues about containment of fluids and securing of tools used on previous missions.

[284] CLINICAL DECISION SUPPORT FOR DEEP SPACE MISSIONSBarbara Burian¹¹NASA Ames Research Center, Moffett Field, CA, USA*(Education - Program / Process Review Proposal)*

BACKGROUND: Deep space missions will often require that crews respond to medical situations without support from ground-based flight surgeons and medical personnel. Clinical decision support systems (CDSS), with a wide range of integrated functions, will be needed to aid crews in this task. This presentation will provide an overview of the major inter-related focal areas and issues associated with augmented CDSS for deep space exploration missions, as well an outline of the needed comprehensive and robust process that properly interleaves these areas in the development these critical aids. **OVERVIEW:** Long lags in communication with ground-based personnel during deep space missions necessitate that crews respond more autonomously to many types of medical situations, particularly those that are unexpected or critical, and the need for such a system is not abrogated even when one of the crew members is a physician. A sophisticated, multi-functional CDSS will help crews accurately assess and diagnose conditions, make decisions about appropriate responses, and guide provision of tailored, evidence-based treatments in light of contextual factors and constraints, such as available diagnostic equipment and medications, and vehicle and environmental health. Not only must a deep space CDSS include the functions of sophisticated CDSS in current use, it must also provide additional capabilities as complex as just-in-time training and as mundane as facilitating delayed communication with flight surgeons on the ground. Its development joins multiple areas involving complex issues involving health and performance monitoring, obtaining and processing biosensor data, knowledge and data management, interoperability, data integration and fusion, advanced algorithm development, and artificial intelligence, among others. Current work in the Exploration Medical Capability Element of NASA's Human Research Program can contribute to the foundation of this CDSS development. **DISCUSSION:** Issues associated with medical knowledge base acquisition, development, maintenance, integration, and fusion; data processing; and CDSS functions and capabilities will need to be understood and addressed if a resulting CDSS for deep space missions is to be usable and effective. Such information is necessary and can also be extended to development of CDSS for use on earth and is particularly relevant for civilian and military remote and telehealth operations.

Learning Objective

- Attendees will be able to identify a minimum of five areas associated with the development of an augmented clinical decision support system for deep space missions and describe some of the ways in which they are inter-related.

[285] TRAUMA/INJURIES DURING SPACE FLIGHTJan Schmitz¹, Steffen Kerkhoff¹, Jochen Hinkelbein¹¹Uniklinik Köln, Cologne, Germany*(Education - Program / Process Review Proposal)*

BACKGROUND: For future space missions, e.g. to the moon or mars, the likelihood of trauma in space increases as well. Living and working in micro-/ hypogravity is, especially in the beginning of a mission, connected with movement in unusual environment. Under this austere environment it is imperative to formulate a plan to manage acute injury or trauma under extraterrestrial conditions. **OVERVIEW:** Next to internal causes of medical emergencies in space, the risk of potential trauma/injury in space is about 10%. Since bone mineral density (BMD) decreases during long-duration spaceflight, the risk of fractures in a microgravity environment is higher. Joint injuries are projected to occur much more often than the more catastrophic bone fracture during exploration class missions, so protecting the integrity of both tissues is important. **DISCUSSION:** In conclusion, the best strategy for mitigating musculoskeletal injuries for long-duration-space missions will be a combination of BMD loss reduction and improvements in management protocols for potential fractures/injuries. Travel distances and mission length will require telemedical solutions as well as the possibility of surgery and medical treatment in

space. In the face of uncertain pathophysiological mechanisms and logistical concerns, potential trauma treatment modalities must consist of adaptive technology, manageability of the crew and ethical aspects. Further investigation in the shape of protocols for trauma, surgical implications, management of an acute bleeding and anesthesia in space is required.

Learning Objectives

- The participant will be able to investigate problems of injury/trauma in space.
- The participant will be able to describe several protocols of trauma management in space.
- The audience will learn about future problems of long-duration-spaceflight and trauma.

[286] MEDICAL EMERGENCIES DURING SPACE FLIGHTJochen Hinkelbein¹¹UK Köln, Köln, Germany*(Education - Program / Process Review Proposal)*

BACKGROUND: During the next years, long-duration space missions will take place and will also be a medical challenge for mankind. Human spaceflight is inherently risky and results in unique problems for emergency medical treatment. On a calculatory basis, 1 emergency will occur in 2.5 years in a crew of 6 astronauts. With increased duration of missions and distance from Earth, medical and surgical events will become inevitable. To enable long-term spaceflights, emergency medical concepts for emergency treatment, anesthesia, and critical care must be developed and are of utmost importance. **OVERVIEW:** In the last years, several papers were published analyzing the probability for different types of emergencies for spaceflight. During the space shuttle flights from 1981 to 1998, N=1867 in-flight medical events occurred but did not result in any fatalities. In this context, medical events are considered relevant but not critical or fatal. From another author, N=17 medical emergencies were reported from 1961 to 1999. However, although no fatalities occurred so far during spaceflight, Trauma (n=2), cardiopulmonary (n=7), internal medicine (n=3), and genitourinary emergencies (n=5) were reported most often and could be the challenges during the next decades. Using this recent data, it may give an idea what emergencies could be relevant also for long-term spaceflight. Since ground-based medical support will no longer be adequate, it is of utmost importance to develop specific both emergency and autonomous medical concepts when return to Earth is not an option. **DISCUSSION:** This presentation is an introduction to the session.

Learning Objectives

- Understand what emergencies could happen.
- Learn the probability of emergencies.
- Learn what organs may be affected.

Wednesday, 05/20/2020**10:30 AM****Centennial IV****[S-57]: PANEL: RESIDENT GRAND ROUNDS II****Chair: Edgar Rodriguez****Co-Chair: David Miller**

PANEL OVERVIEW: This panel will consist of pairs of Aerospace Medicine residents presenting clinical cases of aeromedical interest or significance. During their residency practicum years, residents conduct evaluations of patients with diverse medical problems. Residents prepare and present a case report based on a patient encounter undertaken during their practicum experience. One resident from each pair presents the history of the presented problem. The other resident presents the physical findings and a discussion of the aeromedical policies associated with the condition. Learning Aerospace Medicine at the specialist level involves understanding the impact of medical conditions on aircrew health and mission accomplishment. The cases presented will not only be of academic interest but will also illustrate aeromedical decision making in the operational environment.

[287] MY WINGS ARE WITHIN SIGHTTheresa Long¹¹U.S. Army School of Aviation Medicine, Fort Rucker, AL, USA*(Education - Case Study: Clinical / Human Performance)*

INTRODUCTION: This case report describes a rated military pilot in continuing flight education who presented for an up-slip after being seen for several occurrences "red, painful eyes" oculus uterque (both eyes) over several weeks. **BACKGROUND:** Conjunctivitis is the most common cause of red eye. However, the differential diagnosis is vast and includes, but is not limited to, blepharitis, corneal abrasion, foreign body, subconjunctival hemorrhage, keratitis, iritis, glaucoma, chemical burn, and scleritis. Each of these conditions are a safety risk in flight ranging from distracting to incapacitating. **CASE PRESENTATION:** A 37 year-old active duty pilot with 10 years military service presents to the aviation optometry clinic for evaluation. He reports that he developed red painful eyes that began a couple weeks earlier. The patient reports that he went to a local emergency room (ER) and was given a steroid injection to reduce inflammation. The patient was placed on a temporarily down slip pending further workup. In the aviation clinic, he reports no additional symptoms but has had two further occurrences of same issue since the initial encounter in the ER. **DISCUSSION:** Acute and chronic ophthalmic conditions can have a serious impact on safety of flight. Pursuit of waivers and return to duty requires a thorough review of past medical history, stability of the condition, and appropriate waiverable medication use. The case presentation will include aeromedical disposition and a discussion of Tri-Service/FAA aeromedical regulations related to the case.

Learning Objectives

1. The audience will understand the diagnosis and treatment criteria for the discussed acute and chronic ophthalmic condition.
2. The audience will determine how to aeromedically dispose the discussed ophthalmic condition.
3. The audience will familiarize themselves with appropriate treatment to return the aviator to duty.

[288] A SWEET CASE: SPECIAL ISSUANCE AFTER A SEIZURE DIAGNOSIS IN AN AIR TRANSPORT PILOTMichael F Harrison¹, Clayton T Cowl¹, Lawrence A Steinkraus¹¹Mayo Clinic, Rochester, MN, USA*(Education - Case Study: Clinical / Human Performance)*

INTRODUCTION: This case report describes the process from diagnosis, evaluation, treatment, and application for a special issuance Class I medical certificate following the development of a new seizure disorder. **BACKGROUND:** Epilepsy, transient disturbances of consciousness without satisfactory explanation of cause, or loss of control of the nervous system without satisfactory explanation of cause are among the fifteen disqualifying conditions listed by the Federal Aviation Administration (FAA) for medical certification of pilots. **CASE PRESENTATION:** A 58-year-old-male commercial pilot without an active medical certificate presented to our clinic for in preparation for application for special issuance of a new class I medical certificate. At the age of 51, he developed a new seizure disorder associated with an aura followed by generalized tonic-clonic seizure activity. Following his grounding, he had repeated episodes during the subsequent three years with electroencephalogram (EEG) studies demonstrating interictal epileptiform activity in the right temporal lobe. He was maintained on carbamazepine and presented to Mayo Clinic at age 54 for further evaluation. The only change in his health and lifestyle that he could recall preceding the first seizure was transitioning from a popular sugar-based carbonated beverage to an aspartame-sweetened diet version of the same beverage. He underwent further video-EEG assessments including a fatigue protocol evaluation. An aspartame challenge during a video-EEG evaluation triggered a repeat seizure and the diagnosis of aspartame-induced seizure disorder was made. Following the diagnosis, the pilot began to monitor his diet to avoid aspartame and discontinued carbamazepine therapy. Following a 5-year period of seizure-free observation without anti-epileptic therapy, the pilot obtained a special issuance Class I medical certificate and has returned to work as an Air Transport Pilot. **DISCUSSION:** Aspartame is a widely used food additive as a low-calorie sugar substitute. Aspartame

can increase serum concentrations of phenylalanine, a neurotoxin that reduces the synthesis of inhibitory monoamine neurotransmitters. We present a case of a pilot initially being diagnosed with a disqualifying condition but subsequently being returned to flight status after thorough evaluation, risk mitigation, and appropriate monitoring period.

Learning Objectives

1. The audience will learn about the process required to obtain a special issuance medical certificate for an otherwise disqualifying medical condition.
2. The audience will learn about a rare cause of seizures from a common food additive.
3. The audience will learn about the benefits of a system of open communication between members of a multidisciplinary care team.

[289] A SWEET DISPOSITION FOR A MILITARY PILOT?Kevin Alford¹, Clayton Rabens¹¹USA Air Force, Wright-Patterson AFB, OH, USA*(Education - Case Study: Clinical / Human Performance)*

INTRODUCTION: This case report describes a 36 year old USA Air Force pilot with Latent Autoimmune Diabetes of Adulthood. **BACKGROUND:** Diabetes mellitus (DM) is a common condition encountered in primary care and, increasingly, in aviators. Type I DM is characterized by absolute insulin deficiency often secondary to autoimmune destruction of the beta cells of the pancreas. Conversely, Type II DM results from relative insulin deficiency in the setting of insulin resistance and is often associated with obesity. A small proportion of diabetics have Latent Autoimmune Diabetes of Adulthood (LADA). LADA patients often demonstrate Type I and Type II DM characteristics, as they transition to insulin dependence over months to years after initial diagnosis. **CASE PRESENTATION:** The pilot in this case reported to his flight surgeon that he and a family member, who had newly diagnosed Type I DM, had been enrolled in a clinical research trial studying genetics in diabetes. As part of the study, required lab tests revealed that the pilot had positive auto-antibodies and an abnormal glucose tolerance test. His initial Hemoglobin A1C was 6.5%. He was diagnosed with LADA and started on oral medications. He was granted a Flying Class IIC waiver, restricted to flight with another qualified pilot, valid for one year with a recommendation for quarterly measurements of Hemoglobin A1C to monitor for progression to insulin dependence. Approximately three months after waiver disposition, he presented to an emergency department with abdominal discomfort and altered mental status. **DISCUSSION:** The primary aeromedical risks from diabetes mellitus include the risk for macrovascular events; microvascular complications; and hyperglycemic and hypoglycemic emergencies. Initially, many patients with LADA can be controlled with oral medications. However, they may rapidly transition to insulin dependence. Therefore, aviators with LADA are at increased risk for complications compared to those with the more common Type II DM. This case highlights the challenges in aeromedical disposition for trained aviators with LADA and the importance of considering this diagnosis in the evaluation of newly diagnosed diabetic aviators.

Learning Objectives

1. Understand the aeromedical risks for pilots with Diabetes Mellitus.
2. Identify the characteristics of Latent Autoimmune Diabetes of Mellitus that increase aeromedical risk.

[290] PILOT WITH TESTICULAR CANCER ON ESTROGEN AND PROGESTERONE THERAPYAnn Tsung¹, William Valencia¹¹University of Texas Medical Branch - Galveston, Galveston, TX, USA*(Education - Case Study: Clinical / Human Performance)*

INTRO/BACKGROUND: Gender dysphoria refers to discomfort or distress that is caused by a discrepancy between a person's gender identity and that person's assigned sex at birth. Reports suggest that 0.3 to 0.6% of the adult population is transgender. The diagnosis of gender dysphoria should be made by medical providers who understand the diagnostic criteria and have experience with assessing

the mental health issues that might confound the diagnosis. Transgender patients typically have high rates of mental health diagnoses and screening is recommended for depression, anxiety and other mental health illnesses. Feminizing hormone therapy complications could include VTE, breast cancer, cardiovascular disease, cerebrovascular disease, HTN. Transgender females undergoing gender-affirming therapy should be evaluated every 3 months in the first year and then one to two times per year for adverse reactions.

CASE PRESENTATION: A 30-year-old transgender female (natal male) with history of testicular cancer presented for a special issuance initial exam. In 2005, the patient presented to her PCM with persistent cough. CXR revealed bilateral lung masses and further evaluation found metastatic testicular cancer which was treated with chemotherapy followed by right thoracotomy with right lung resection. Pt was followed regularly with tumor markers for 10 years and continued to undergo scheduled imaging surveillance. Pt reports symptoms of gender dysphoria since she was 3-4 years old. She began her hormonal transition in 2016 with oral estradiol and spironolactone. Her current regimen is subcutaneous estradiol and topical progesterone, started in 2018. She denies any side effects from medications. She plans to undergo penile inversion surgery in 2 years. **DISCUSSION:** A FAA CACI (conditions airmen can issue) and AME (Air Medical Examiner) Assisted Special Issuance exist for testicular cancer. Consideration factors include current status report, treatments, time frame, and presence of metastasis. An FAA CACI is available for gender dysphoria which includes timeframe, hormonal replacement, surgery, and any mental health issues. A Gender Dysphoria Mental Health Status Report is required from the AME. Oral hormonal replacement is not disqualifying for medical certification and will depend on existence of adverse effects. Air Force, Navy and Army standards are also reviewed.

Learning Objective

1. Understand the aviation clinical considerations and certification requirements for testicular cancer, hormonal therapy and gender dysphoria.

[S-57-A] ACUTE LOW-TONE HEARING LOSS; SELF-LIMITED DISEASE OR CAREER ENDING CONDITION?

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(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: This case report describes an active duty army pilot with history of acute low-tone sensorineural hearing loss without vertigo. **BACKGROUND:** Acute low-tone sensorineural hearing loss (ALHL) is characterized by acute onset, low-tone hearing loss often associated with tinnitus, ear fullness, and/or autophony, without vertigo. In addition, the clinical characteristics and hearing prognosis of ALHL differ from idiopathic sudden sensorineural hearing loss (SSNHL). In some cases, ALHL associates with endolymphatic hydrops or Meniere's disease and recurrence or fluctuation is relatively common. Some ALHL patients develop typical Meniere's disease over a long-time follow-up period. **CASE PRESENTATION:** The subject is a 37-year-old, male Japan Ground Self-Defense Force UH-1 pilot. The subject developed left-sided tinnitus and ear fullness, with no reported vertigo or dizziness. Pure-tone audiometry showed left-sided low-tone hearing loss. No spontaneous nystagmus was observed, but the Fukuda stepping test revealed greater than 90 degrees deviation to the right; suspicious for a weak equilibrium disorder as well as ALHL. The subject was treated with steroid therapy subsequently followed by resolution of the ALHL and normalization of the Fukuda stepping test. Since recovery there has been no evidence of recurrence. Six months after treatment, the subject was evaluated by the Japan Air Self-Defense Force Aeromedical Consultation Service. **DISCUSSION:** ALHL has recently been classified as an independent disease because of its good short-term hearing recovery prognosis with no evident vertigo. However, in the long term, some patients develop Meniere's disease suggesting that ALHL may be caused by cochlear endolymphatic hydrops like Meniere's disease. Although the subject did not report vertigo and nystagmus was not observed, an abnormal Fukuda stepping test was demonstrated. It is important to note that while this

subject had an atypical ALHL presentation, this case was not a stereotypical presentation of Meniere's disease. Therefore, it was not unreasonable to consider a waiver for continued aviation duties. However, periodic follow-up is considered necessary to mitigate occupational risk, since even fully-recovered ALHL patients may subsequently develop Meniere's disease.

Learning Objectives

1. Review the aeromedical policies of the U.S. Department of Defense, Federal Aviation Authority, and international aviation standards for acute low-tone sensorineural hearing loss.

[S-57-B] AEROMEDICAL DISPOSITION OF AN 'UNPREDICTABLE' DISEASE- MULTIPLE SCLEROSIS

A.K.M. Al Mamun¹ and T.Y. Elbakry²

¹Aeromedical Institute, Bangladesh Air Force; and ²Egyptian Airforce Medical Services

(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: This case report describes a full-time Air National Guard F-15 senior pilot with a history of recurrent optic neuritis, frontal lobe white matter hyperintensities, and a disputed diagnosis of multiple sclerosis. **BACKGROUND:** Multiple sclerosis (MS) is the most common immune mediated inflammatory demyelinating disease of the central nervous system. Some specific clinical manifestations typify MS; however, the disease has variable timing, duration, and atypical presentations. When considering MS in the differential diagnosis, one must carefully consider the needs of the individual and the mission while giving due diligence to aviation safety. When the disease presentation is atypical, adhering to proven diagnostic criteria may not contribute substantially to risk management and aeromedical decision making. **CASE PRESENTATION:** This accomplished senior pilot initially presented at age 31 years, complaining of unilateral vision changes. Medical evaluation revealed diminished OD color vision with optic disc pallor and a nonspecific left frontal white matter hyperintensity on MRI. After several weeks of observation, his unit flight surgeon returned him to flight status without a waiver despite persistent, color deficiency. Seven years later he again noted decreased vision OD with progressive 'fogginess' in contrast sensitivity. Ophthalmology diagnosed him with optic neuritis and treated him with a three-day course of intravenous methylprednisolone. He returned to baseline eight days later. Over the next two years, serial MRIs revealed several new white matter hyperintensities. He was given a diagnosis of multiple sclerosis and started long-term treatment. The pilot contested the diagnosis despite independent confirmation. The USAF Aeromedical Consultation Service recommended permanent disqualification. After personal research, consultation with multiple physicians and alternative diagnoses, the subject presented a civilian neurology consult recommending return to flying F-15s with no restrictions. 15 years following his initial presentation, the subject was once again evaluated at the USAF ACS for waiver consideration. **DISCUSSION:** Optic neuritis (ON) may be an isolated diagnosis or an indicator of MS. Both conditions are disqualifying for flight status, and clinical manifestations may go unrecognized by the aircrew regardless of treatment. Visual disturbances have the potential to impair the aviator's visual performance and may present a significant safety hazard or adversely impact mission effectiveness. In addition, MS may manifest with overt or insidious cognitive impairment in about 50% of cases. Both conditions can be aggravated in the stressful aviation environment. Unfortunately, no biochemical or radiographic markers exist to predict progression or severity of symptoms; a period of observation is indicated but defining the duration of observation remains unclear. In addition, to an unpredictable disease course, disrupted sleep and treatment effects must be considered in the risk management calculus.

Learning Objectives

1. Review the aeromedical policies of the US Department of Defense, Federal Aviation Authority, and International government standards as they relate to this diagnosis.
2. Review aeromedical implications of a serious disease with an unpredictable course.

Wednesday, 05/20/2020
Regency 6

10:30 AM

[S-58]: SLIDE: SPINAL PAIN & INJURY

Chair: William Dodson

Co-Chair: Danny Pizzino

[291] NECK PAIN IN RCAF FAST JET PILOTS: PREVALENCE, CHARACTERIZATION AND OPERATIONAL IMPACT

Erin Smith¹

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(Original Research)

INTRODUCTION: Neck pain is increasingly prevalent in the international aviation community. Previous studies conducted within the Royal Canadian Air Force (RCAF) have established that operationally significant neck pain is prevalent in RCAF rotary wing aircrew. While it is well established that fast jet pilots are also at risk of neck pain and injury, the RCAF fast jet pilot population has not yet been studied. The results of this survey will provide much needed insight into the proportion of the RCAF fast jet population affected by neck pain and to what extent this affects operations and quality of life. **METHODS:** All RCAF fast jet pilots received a presentation on neck pain and were provided an opportunity to complete a 30-45 minute on-line anonymous survey using *FluidSurvey*. This survey was the first to include the 'Core Questions' recommended by the NATO HFM RTG 252. All RCAF fast jet pilots were eligible to participate, including International Instructor Pilots and Student Pilots and those in non-flying positions at the time of data collection. There were no specific exclusion criteria. Ethics approval was obtained from DRDC's Human Research Ethics Committee. **RESULTS:** 229 pilots completed the on-line survey resulting in an 85% completion rate. The lifetime prevalence of significant neck pain in RCAF aircrew was reported as 57%. Of those, 90% reported a lifetime prevalence of significant *flight-related* neck pain, 77% in the last 12 months and 50% in the last 3 months. Aircrew reported an average of 1-4 episodes in the last 12 months, typically lasting 7 days or less. 63% of RCAF fast jet pilots report modifying their flying activities due to neck pain and 57% report modifying their activities of daily life due to significant flight-related neck pain. Worsening symptoms, fear of additional injury and fear of impact to quality of life were reported as the primary reasons for modification of activities. **DISCUSSION:** This study confirms that neck pain is a significant problem in RCAF fast jet aircrew and has a significant impact on the health and operational capability of the RCAF Fighter Force. While there is still much to learn, this information can be utilized to direct future efforts towards further characterization of the contributing factors, minimizing impact to operations and mitigating the risk of further injury.

Learning Objective

1. To understand the prevalence and operational impact of neck pain in RCAF fast jet aircrew.

[292] DIFFERENCES IN ELECTROMYOGRAM PROFILE OF NECK MUSCLES IN SUBJECTS WITH AND WITHOUT NECK PAIN

Sven Rochelt¹, Janine Rochelt¹, Nadja Saba¹, Denis Bron¹, Andres Kunz¹

¹Swiss Air Force Aeromedical Center, Dubendorf, Switzerland

(Original Research)

BACKGROUND: Neck pain is a growing medical problem among military Air Force pilots. Strong G-forces, vibration, additional helmet weight and a non-ergonomic sitting posture can lead to muscular tension and neck pain. Muscle activity can be measured by surface electromyography (sEMG). EMG signal is used to monitor fatigue of a particular muscle. The purpose of this study is to use sEMG signal to determine differences in neck muscle activity in military pilots with non-specific neck pain and without neck pain. **METHOD:** Twenty military pilots and twenty control subjects participated in this study. Each subject group consisted of ten participants with acute or chronic neck pain and ten without. All subjects performed one reference movement and seven exercises in a standardized

way. Simultaneously, a sEMG recorded the specific activity of defined muscles. Visual analogue scale (VAS) reported pain experience. To query the subjective state of health, the Bournemouth questionnaire was used. A wavelet analysis was also applied on the sEMG pattern. For inter-individual analysis, data of the performed exercises was normalized to the reference movement. **RESULTS:** The firing frequency of left trapezius muscle in group Symptomatic Pilots was significantly higher ($p < 0.05$) than those of the other groups for arm abduction, shoulder lifting, shoulder rotation and teacup left. Furthermore, a shift to the lower frequency spectrum could be reported in the right trapezius muscle for shoulder lifting, shoulder rotation and teacup right respectively. No significant differences could be found in head inclination nor head rotation between all groups, as well as in the other recorded muscles. **DISCUSSION:** The increased intensity could be explained by the fact that the affected muscle in question fires more frequently and therefore, fatigues faster. Moreover, a tired or painful muscle shows a frequency shift to the lower frequencies. This shift may be related to an impairment of fine motor skills, which are the basis of a good functionality of the deep muscles of the cervical spine. This could imply that the support function of the deep neck muscles is no longer guaranteed in neck pain pilots. In summary, inter-individual differences could be shown, especially in pilots and non-pilots. Further investigations are needed to substantiate these results in order to develop a preventive tool to counteract neck pain in Air Force Pilots.

Learning Objectives

1. Understand the importance of prevention of neck pain in Military pilots.
2. Wavelet Analysis can be used to evaluate EMG raw data.
3. The Change in Amplitude and frequency spectrum can be an indicator for neck pain.

[293] AN ASSESSMENT OF CERVICAL SPINE RANGE OF MOTION REQUIREMENTS FOR AH-64 AVIATORS RELATIVE TO TIME OF DAY

Steven Williams¹, Fred Brososki¹, Adrienne Madison¹, Valeta Chancey¹

¹U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA

(Original Research)

INTRODUCTION: Neck pain is an established flight safety issue for military rotary-wing aviators. Military flight surgeons tasked with making determinations regarding an aviator's flight fitness based on cervical spine range of motion (CROM) do not have adequate guidance to make an informed decision as there is currently no regulation defining what range of motion is adequate during flight operations. Describing the real-world CROM during flight would inform flight surgeons and provide a more useful and substantial reference than the physiological normal limits that flight surgeons currently employ. USAARL is conducting a study among AH-64 and UH-60 pilots to characterize CROM requirements in simulated and actual flight using optical head tracking equipment. One area of investigation is CROM differences relative to time of day. **METHODS:** Three-dimensional pilot and co-pilot head position data from the maintenance data recorder (MDR) readings from AH-64 missions were provided by Apache Attack Helicopter Project Management Office. Data were filtered down to three-dimensional pilot and co-pilot head position data reported as unit vectors. Missions were classified as either day or night flights. Each data point was analyzed to determine neck posture. Neck postures were then categorized as neutral, mild, or severe for flexion/extension, lateral bending, and axial twist based on neck postural categories from the work of Punnett et al. (1991). **RESULTS:** Presented here is an analysis of head position data from pilots and co-pilots during a collection of day and night AH-64 flights. Preliminary analysis of a small data sample showed a higher frequency of head movement during night flights. These preliminary results also showed greater cervical activity with co-pilots compared to pilots (during day and night flights). The length of time in each posture category was also greater during night flights for both pilots and copilots. **DISCUSSION:** This investigation provides a preliminary assessment of AH-64 CROM during day and night flight missions. Limitations of the analysis to consider include the type of aircraft being flown, the type of mission being performed, and the conditions of the flight, which could lead to varying CROM requirements. Accordingly, future research will occur in both actual and simulated flight in both an AH-64 and UH-60 where the mission and

flight conditions can be controlled and a statistical evaluation can be performed.

Learning Objectives

1. The audience will learn about cervical spine range of motion requirements for AH-64 aviators during routine flight respective to time of day.
2. The audience will learn about the postural categories used to analyze head position data.
3. The audience will learn about the differences in cervical spine range of motion between pilots and copilots.

[294] EFFECTS OF ADDITIONAL AXIAL LOAD ON MOTOR CONTROL OF THE HUMAN CERVICAL SPINE

Ursula Heggli¹, David Rafique²

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²Integrative Spinal Research ISR, Department of Chiropractic Medicine, Balgrist University Hospital, Zurich, Switzerland

(Original Research)

INTRODUCTION: The cervical motor control (CMC) is the result of different stabilization mechanisms produced by the passive, active, and neurological subsystems. The joint position error test (JPE) was developed to quantify changes in cervical proprioception in patients with neck pain. Jet pilots need full mobility of their neck during air combat, while they are exposed to axial G- loads. Helicopter pilots on the other hand, have longer flight times while they are wearing a helmet and potentially a night vision goggle. To prevent neck disorder, a better understanding of cervical motor control under axial load is needed. **METHODS:** 51 healthy young men (mean age of 20.3 ± 1.4 years) were recruited for this study. With an accelerometer (IMU) strapped to the forehead, a sensarmove cervical trainer device measured cervical JPE and range of motion (ROM). We assessed in random order 0 or 3 kg (6.6 lbs.) of additional axial load in flexion, extension, rotation, and lateral-flexion. For the statistical comparison we used the paired t- test (SPSS program). **RESULTS:** In the JPE- test, extension ($p = .028$) and flexion ($p = .004$) showed significant larger deviations (errors) with an additional axial load of 3 kg (6.6 lbs.) compared with zero, whereas the changes in the rotation ($p = .997$) and lateral-flexion were not significant ($p = .267$). In the ROM, there were two significant changes with axial load: an increase in the lateral- flexion ($p = .004$) and a decrease in flexion ($p < .001$). ROM of extension ($p = .655$) and rotation ($p = .178$) did not change. **DISCUSSION:** CMC seems to get worse under axial load, especially in flexion and extension. A reduced CMC could lead to neck injury or neck pain. This could be one reason why jet pilots often have neck problems. The decrease of the ROM in flexion can be explained by a protective mechanism in response to the unstable position. In contrast, the length of the lateral neck muscles could limit the ROM in the lateral- flexion. **CONCLUSION:** To prevent neck pain in military pilots a stabilization and proprioception neck training is essential.

Learning Objective

1. How does axial load affects the motor control and the range of motion of the cervical spine.

[295] PRELIMINARY INJURY ASSESSMENT REFERENCE VALUES FOR THE SPINE UNDER VERTICAL LOADING

Elizabeth Lafferty¹, Ray Daniel¹, Katie Logsdon¹,

Edward Mazuchowski², B. Joseph McEntire³, V. Carol Chancey³

¹U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA;

²Armed Forces Medical Examiner System/Joint Trauma System, Joint Base San Antonio, Houston, TX, USA; ³Fort Rucker, AL, USA

(Original Research)

INTRODUCTION: This study developed injury assessment reference values (IARVs) for new crashworthy seats by evaluating the response measurements of anthropomorphic test devices (ATDs) during vertical impact acceleration tests matched to post mortem human subject (PMHS) tests resulting in spinal injury. Analysis of injury patterns in U.S. Army aviation mishaps reveals a strong relationship between vertical impact dynamics and spinal injuries. A landmark rotorcraft seat crashworthiness standard is MIL-S-58095A, which predates spinal injury metrics and does not require direct measurement of the lumbar forces in ATDs. Instead, it measures reactionary seat pan accelerations to assess

vertical seat performance. By assessing the lumbar forces directly, the correlation between laboratory measurements and injury risk can be improved. **METHODS:** Impact acceleration tests included 11 PMHS specimens and 21 matched-pair ATD tests that were conducted on the USAARL Vertical Acceleration Tower. ATD types included both the standard Hybrid III and Federal Aviation Administration (FAA) Hybrid III configuration with a modified lumbar spine. PMHS and instrumented ATDs were exposed to vertical acceleration pulses matching the MIL-S-58095A standard as well as exposures with lower maximum acceleration and onset rates. The Abbreviated Injury Scale (AIS) was used to quantify the PMHS injuries to the spine and pelvis. These injury outcomes were matched to ATD vertical compressive lumbar loads and survival analysis was used to create injury assessment risk curves and associated IARVs. IARVs were selected to control for a 5% risk of serious (AIS3+) injury to the occupant. **RESULTS:** All PMHS received injuries ranging from AIS 1 to AIS 4 (minor to severe). Frequent injuries included vertebral fractures, ruptured discs, and rib fractures. The developed IARVs controlled for a 5% risk of serious (AIS 3+) injury where the lumbar z-axis load cell should not exceed 1370 lbs in an FAA Hybrid III ATD and 1240 lbs in a Hybrid III ATD. **DISCUSSION:** The extent of the injuries documented when PMHS were exposed to conditions allowed by the military dynamic standard indicates that the current standards do not sufficiently protect the occupant from spinal injury during a survivable crash. The developed IARVs should either replace, or be incorporated into, the current military vertical impact crashworthy seat standard for improved occupant protection from spinal injury.

Learning Objective

1. The audience will learn about current military energy attenuating seat testing standards and recommendations on improved injury criteria to better protect rotary-wing aviators.

[296] METHODOLOGY FOR MATCHING LEGACY ACCELERATIVE EXPOSURES ACROSS MULTIPLE SUBJECT TYPES

Shannon McGovern¹, Ardyn Olszko¹, Alicia Abraczinskas¹,

Kristen Trenary¹, Christine Beltrane¹, Kimberly Vasquez¹,

Valeta Chancey¹

¹U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA

(Original Research)

INTRODUCTION: The Biodynamics Data Resource at the U.S. Aeromedical Research Laboratory houses data for ~7,000 non-contact inertial loading exposures (non-injurious and injurious) from vertical and horizontal sled runs previously conducted at the Naval Biodynamics Laboratory (1971-1996). Kinematic and/or physiologic responses were measured from human research volunteers (HRVs) (only non-injurious), anthropomorphic test devices (ATDs), and non-human primates (NHPs). Therefore, data can be used to develop human injury criteria; however, a methodology is first needed to match non-injurious parameters across subject types to allow the non-injurious human responses to be extrapolated to injurious ranges. **METHODS:** Twenty-six parameters (peak sled acceleration, impact direction, etc.) were scored as high, medium, low, or negligible and classified as numeric or categorical. Classifications were made using multiple statistical assessments. Two processes were used to determine tolerances on numeric parameters: classifying parameters into statistical distributions and equal-frequency varying-bins histograms. Tolerances were selected from equal-frequency varying-bins histograms based on largest bin size. Data were matched based on exact categorical parameters and numeric parameters within tolerance range. **RESULTS:** Fifteen of the parameters had high priority classification: categorical (6) and numeric (9). The data spread for most of the numeric parameters were right-skewed and none fit a known statistical distribution. All HRV exposures fell within the range of the ATD and NHP exposures for all parameters. Equal-frequency varying-bins histograms determined a static frequency per parameter, allowing for bin sizes and number of bins (16 to 80) to vary. The largest and smallest tolerances of all parameters encompassed 94.79% and 15.94% of the range, respectively. All parameters were matched between subject types, but not across all three subject types. **DISCUSSION:** The right-skewness of the numeric parameters was due to higher ATD and NHP (injurious) exposures, causing selected tolerances to encompass a large percent of each parameter range. While this generated matches, no matched group contained all three subject types despite large tolerances. Future work will apply these methods solely for the range of

HRV and will investigate decreasing to next largest bin sizes as tolerances to optimize groups with matched parameters.

Learning Objective

1. The audience will learn a methodology for matching datasets across multiple subject types for a variety of matching parameters, where parameters include both numeric and categoric.

Wednesday, 05/20/2020

10:30 AM

Regency 8

[S-59]: PANEL: THE HISTORICAL NEED AND CURRENT TRAJECTORY OF HYPOXIA TRAINING

Chair: Jonathan French

PANEL OVERVIEW: This panel will examine significant historical steps in our current understanding of altitude induced hypoxia, how this has influenced air crew training and some possible new directions for research and training. Recent Physiological Events (PE's) in military aircraft such as the T-6 and the F-22 have highlighted the need for continued hypoxia awareness training and for continued research into hypoxia symptoms. New devices and new training ideas are discussed that will make this training and research less costly, more available and more efficient than ever before. The first presentation describes the historical recognition of the need for hypoxia training, so called "oxygen discipline" that began just before and after America's entry into WWII. Within a few years, combining science and hypobaric training dramatically reduced fatalities and injuries in unpressurized aircraft. The second presentation illustrates how normobaric hypoxia training technology are used in NATO to supplement traditional hypobaric protocols, which have grown more sophisticated as the airframes and mission demands have become more complex. Both the US Air Force and Navy have also gravitated towards various methods of normobaric recurrent training. The third presentation reviews the current use of on demand and individual hypoxia trainers in athletes and aircrew to improve endurance and awareness of hypoxia effects. These individual trainers represent a third generation of hypoxia generating systems for training and research. The fourth presentation demonstrates the need for a closer look at the individual in hypoxia awareness training to determine who is more at risk and what symptoms might one show. Finally, the last presentation argues that mild hypoxia may accelerate the onset and effects of spatial disorientation and that spatial disorientation awareness should be included in hypoxia training. This panel encourages the discussion of renewed awareness of hypoxia dangers and new approaches to facilitate current hypoxia training efforts.

[297] MILD HYPOXIA MAY ACCELERATE SPATIAL DISORIENTATION

John French¹, Alexandria Orr¹, Megan Prichett¹, Manon Doan²

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²French Air Force Academy, Salon-de-Provence, France

(Education - Tutorial Proposal)

INTRODUCTION: Over the last 10 years, there has been a dramatic increase in hypoxia related physiological events in the military, resulting in fatalities and the grounding of particular high performance aircraft. These events have highlighted an unprecedented re-examination of aviation related hypoxia effects and countermeasures to supplement the mechanical fixes. **TOPIC:** Evidence was found in the literature that implicates spatial disorientation as a co-factor in hypoxia related performance effects. While the effects of acceleration on vestibular function has been well studied, sparse attention has been given to the effects of hypoxia on the vestibular sense. Vestibular related spatial disorientation (SD) has long plagued general aviation as one of the leading causes of fatalities. Reports that mild hypoxia, between 8,000 feet and 10,000 feet, may have effects on postural stability and thus may be the first physiological symptom of hypoxia. These effects would be missed in hypoxia chambers since traditionally, everyone is sitting. This has implications for training and countermeasures somewhat different from those that only consider hypoxia during the physiological events. In a preliminary investigation, we tested six flight instructors on their postural stability at sea level and at 12,000 feet equivalent altitudes using

a portable hypoxia generating mask in a double blinded manner. Since otolith stimulation produces the centrifugal G forces to misrepresent the horizon, it was necessary to test for these effects in a motion condition rather than simply sitting in a hypoxia chamber. We used a Barany chair and a virtual reality based optokinetic experience to induce vestibular effects and then measured postural stability on a pressure pad. More of the pilots showed postural impairment in response to vestibular stimulation. Since we did not see color vision effects at this equivalent altitude and we expected to, we believe we need a longer period of hypoxia and a larger sample. **APPLICATION:** Implications for military and GA aviation, countermeasures current and proposed and recommendations for future research will be discussed. In addition, there are important considerations for loss of balance in elderly who may have poor circulation but good vision. **RESOURCES:** Kowalczyk, K. P., Gazdzinski, S. P. et al., (2016). Hypoxia and Coriolis illusion in pilots during simulated flight. *Aerospace Medicine and Human Performance*, 87(2), 108-113.

Learning Objectives

1. The audience will learn the effects that moderate hypoxia has on postural sway and possibly why.
2. The audience will consider if hypoxia awareness and spatial disorientation awareness training should be covered together.
3. The audience will consider the possibility that elderly falls might be related to proprioception impairment

[298] PHYSIOLOGICAL RECOGNITION OF HYPOXIA AND NEW TRAINING SYSTEMS FOR ATHLETES AND AIRCREW

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¹Embry-Riddle Aeronautical University, Daytona Beach, FL, USA

(Education - Tutorial Proposal)

INTRODUCTION: Since the days of the first lighter than air balloons aviators often died from what must have been frightening new forces in the ether. Aviators still die if unprepared for hypoxia. We are only now unraveling the medical importance of hypoxia. Otto Warburg won the Nobel prize in 1931 for elucidating the pathologies of inadequate cellular respiration, particularly cancers. This work led Guyton to conclude that "all chronic pain, suffering and diseases are caused from a lack of oxygen at the cellular level". The importance of this topic was again highlighted by the 2019 Nobel Prize in physiology to 3 scientists for advancing our understanding of oxygen regulation at the cellular level. **TOPIC:** The more immediate effects of hypoxia create the most problems for aviators. It is well known that hypoxia affects the central nervous system first and disproportionately to other systems. This is particularly insidious since the oxygen deprived individual will have difficulty recognizing and responding to their situation in time to save themselves. The costs and difficulties of maintaining a hypobaric chamber for hypoxia awareness training has been circumvented by the normobaric hypoxia chambers. A third device, individual hypoxia generators, have made it even easier to get supplemental training for a larger number of aviators than ever before. The use of hypoxia generators to stimulate the production of erythropoietin (EPO) and increase aerobic endurance has been well known since the 1968 Olympics in Mexico City favored those who had trained at high altitudes. The On Demand Hypoxia Trainer (ODHT) was designed more recently to fit the training needs of pilots in high performance aircraft. There is a need for an FAA approved protocol for these newer systems that will allow aviators to recognize the earliest symptoms of hypoxia. **APPLICATION:** A concern to be discussed is the absence of hypobaric conditions in the normobaric and ODHT devices on physiological hypoxia like that derived from high altitude. This discussion will focus on the uses of individual hypoxia devices for aircrew training. **RESOURCES:** Guyton, A.C., 1976, Textbook of Medical Physiology, DeHart, R.L, Davis, J.R. 1986, Fundamentals of Aerospace Medicine.

Learning Objectives

1. The audience will learn important new findings in cellular hypoxia.
2. The audience will understand the advantages and disadvantages of individual hypoxia awareness training devices.

[299] HYPOXIA TRAINING IN THE NORWEGIAN ARMED FORCES: LESSONS LEARNED AND FUTURE PLANS

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¹Oslo Metropolitan Collage, Oslo, Norway

(Education - Tutorial Proposal)

INTRODUCTION: Hypoxia awareness has long been required physiological training for military aviators. The need for it came about after a tight symbiosis with academics on the subject at the outset of WWII and it has left lasting impressions on every aircrew trained since. **TOPIC:** Norwegian chamber operations began in 1955, since 1978 records show over 7000 training exposures. There are three main profiles: 16000 ft (Helicopter) which accounts for 31% of total exposures, 25000 ft with 3 sec Rapid decompression (RD) accounting for 9% total exposures and 25000 ft with 12 sec RD accounting for 60% of total exposures. For both of the 25000 ft profiles the de-nitrogenization time is 45 min. The RD is introduced prior to the hypoxia training and ascends the students from 8000ft to 25000ft. Here they are exposed to hypoxia in one of two sessions for no longer than 4 min 30 sec each, followed by a descent to 17000 ft for a 7 min long hypoxia and night vision acuity test. Each student is equipped with a pulse-oximeters and chamber oxygen sensors which monitor the ambient air to secure a strict 21% O₂ concentration. Normobaric hypoxia (ROBD) training was added in 2017 when a requirement for annual hypoxia training for F-35 pilots was introduced. The ROBD has hypoxia onset at 16000 ft then proceeds to 25000 ft. The NATO STANAG 3114 stipulates initial training for aviators before flying commences and a refresher every 5 years throughout their career. **APPLICATION:** The pedagogical environment surrounding chamber training gives a long lasting learning effect and history has shown it can be done safely. Accordingly, the chamber flight is the primary training platform and introduce the ROBD as a platform for annual F-35 hypoxia training. For all active duty, there is a chamber flight initially and every 5 years thereafter. For the F-35 pilots annual ROBD is mandated the 4 years in between chamber flights. These 4 years will be used for more recovery focused training in more sophisticated scenarios.

Learning Objectives

1. The audience will learn how past lessons learned can secure a safe and effective hypoxia awareness training.
2. The audience will understand the use of new techniques and technology, like the ROBD, can help guide the future trajectory of hypoxia training.

[300] HIGH-ALTITUDE TRAINING AND OXYGEN DISCIPLINE IN THE U.S. ARMY AIR FORCES (USAAF) DURING WORLD WAR II (WWII)Jay Dean¹¹University of South Florida, Tampa, FL, USA*(Education - Tutorial Proposal)*

INTRODUCTION: WWII was the world's first high-altitude air war and pilot performance and victory depended on good "oxygen discipline" by U.S. airmen fighting in unpressurized warplanes. To this end, aviation physiologists developed America's first large scale hypobaric hypoxia awareness training program that ultimately reduced flyer fatalities during high altitude operations. **TOPIC:** In 1940, however, America's aeromedical research and altitude training programs had only 3 research laboratories (Wright Field, Mayo Clinic, and Harvard School of Public Health). The U.S. National Research Council's Committee on Aviation Medicine (Oct 1940-Dec 1945) combined with increased government support for expansion of U.S. military aeromedical labs at Wright Field, Randolph Field, and Naval Air Station Pensacola, and funding of academic research labs, soon corrected this deficiency in America's war preparedness. By 1945, America's aeromedical research and training programs were without equals. **APPLICATION:** The high-altitude training program in the USAAF employed over 200 aviation physiologists at 45 Army airfields who made ~700,000 simulated flights in 65 altitude chambers at the rate of more than 58,000 men per month during 1945! The altitude chamber was viewed as the best tool for instruction in the correct use of O₂ equipment (good oxygen discipline). The military's goal was to reduce the incidence of accidents from failure of O₂ equipment through instruction accompanied with demonstrations in the use of the equipment and in the physiological effects of O₂ want. As a result, the trend in anoxia accidents in unpressurized heavy bombardment crews in the U.S. Eighth Air Force (1943-Nov 1944) decreased by 80% and fatalities from anoxia decreased by 68%. By 1942, efforts to classify flying personnel

based on their O₂ ceiling became less important than classification as to their resistance to aeroembolism; e.g., aviators that qualified for high altitude flying missions "withstood decompression at altitudes as prescribed in flight schedules [35,000-40,000 feet] for four hours without severe symptoms [of decompression sickness]." In addition to O₂ discipline, aviators were taught prevention of decompression sickness with O₂-prebreathing, appropriate use of bailout O₂ equipment, and how to survive an explosive decompression if assigned to the new, pressurized B-29 Superfortress very heavy bomber.

Learning Objectives

1. The participant will learn about the origins of the high altitude indoctrination programs in the U.S. military during WWII.
2. The participant will learn about the rationale for using the altitude chamber as a training tool.
3. The participant will learn about the goals of altitude training and pilot selection and the outcome of America's oxygen/altitude training program during the war.

[301] UNDERSTANDING THE RELATIONSHIP BETWEEN DEMOGRAPHICS AND HYPOXIA SYMPTOMS IN TRAINING ENVIRONMENTSRichard Simonson¹, Joseph Keebler¹¹Embry-Riddle Aeronautical University, Daytona Beach, FL, USA*(Education - Tutorial Proposal)*

INTRODUCTION: Our ability to prepare for and predict a hypoxic event is based on our knowledge of various environmental and personal factors and symptoms that are present in pilots. This presentation describes analyses to understand the latent factors of hypoxia symptoms and pilot demographics as well as a set of linear models for predicting various symptoms of hypoxia. **TOPIC:** Symptoms and demographic variables were collected from a set of approximately 100 participants who were active Navy aircrew during new and refresher hypoxia training using the Reduced Oxygen Breathing Device (ROBD). We collected an array of common symptom data affiliated with hypoxia (air-hunger, confusion, cyanosis, etc.) and their associated severity (low, medium & high), as well as demographic data (exercise routines, sleep patterns, and caffeine, alcohol, and tobacco use). Two analysis methods were applied to the data. First, factor analysis was utilized to reduce the number of variables in the data set for more manageable analysis. Following, regression analyses were then conducted with the resulting factors to assess demographic predictors and correlates of symptoms. The factor analysis first utilized parallel analysis to develop a set of *a priori* cutoff values. The parallel analysis lead us to retain 9 factors for symptoms – cyanosis, confusion, tingling, air hunger, difficulty speaking, lack of coordination, hot flashes, difficulty concentrating, and cold flashes. We also extracted 4 factors for the demographic variables including experience, mental health physical health, drugs. Following, we conducted regression analyses to understand the influence of the 4 demographic factors on the 9 symptom factors. This resulted in 4 significant models: confusion predicted by experience tingling predicted by experience and mean heart rate; air hunger predicted by experience, mean heart rate, and irregular low heart rate, and difficulty concentrating predicted by experience, mean breathing rate, and irregular low heart rate. **APPLICATION:** These results contribute to a baseline foundation for future research to study the correlation between observable symptoms and self-reported symptoms, but more work is needed to better understand these phenomena. This talk will discuss the potential of future research in further individualizing hypoxia training by identifying symptom and demographic factor relationships for personalized training algorithms.

Learning Objectives

1. The audience will learn about a high-level overview of factor analysis and regression techniques, and how they can be applied in this setting.
2. The audience will learn about how hypoxia can be studied in an aviation training environment.
3. The audience will learn about how individualized hypoxia training algorithms can be an effective new tool for a diverse population.

Wednesday, 05/20/2020
Centennial I

2:00 PM

[S-60]: PANEL: U.S. AIR FORCE DISTRIBUTED COMMON GROUND SYSTEM INTELLIGENCE OPERATORS

Chair: Lillian Prince

PANEL OVERVIEW: This panel presents the results from a 2019 occupational health assessment given to the U.S. Air Force (USAF) distributed common ground system (DCGS) intelligence community. The assessment was conducted by USAF School of Aerospace Medicine researchers to identify the unique characteristics of the DCGS operational environment. We will provide a broad-spectrum snapshot of occupational health for these USAF operators and draw comparisons to findings from previous assessments of this population in 2011, 2013, and 2016. The present study was reviewed and granted exemption by the Air Force Research Laboratory Institutional Review Board at Wright-Patterson Air Force Base and assigned protocol number F-WR-2011-0070-E. The first presentation gives overarching findings from the occupational health questionnaire and introduces psychological distress. The second presentation introduces post-traumatic stress disorder (PTSD) and specific symptom endorsement from the PTSD Checklist. The third presentation addresses both positive and negative coping strategies employed by this population for psychological distress and PTSD. The fourth presentation addresses the importance of unit and member social support for the DCGS community. The fifth presentation gives a psychological review of the reported moral issues and spirituality and their relationship with psychological distress and PTSD in this population.

[302] DISTRIBUTED COMMON GROUND SYSTEM OCCUPATIONAL HEALTH QUESTIONNAIRE RESULTS: SOURCES OF STRESS AND RATES OF PSYCHOLOGICAL DISTRESS

Lillian Prince¹

¹U.S. AIR FORCE SCHOOL OF AEROSPACE MEDICINE, Birmingham, AL, USA

(Original Research)

INTRODUCTION: The increasingly dynamic state of global political and military affairs sustains the high demand for distributed common ground system (DCGS) capabilities. The nature and magnitude of missions conducted by DCGS intelligence operators impart unique stressors. Thus, the need to monitor stressors, psychological distress, and associated risk factors is critical to the success and livelihood of these individuals. **METHODS:** The present study included 1007 DCGS intelligence operators who responded to a comprehensive occupational health assessment that included questions on demographics, sources of stress, health and occupational factors, and stress outcomes. The Outcome Questionnaire was used to assess psychological distress. The study was reviewed and granted exemption by the Air Force Research Laboratory Institutional Review Board at Wright-Patterson Air Force Base and assigned protocol number F-WR-2011-0070-E. Rates of psychological distress were examined and comparisons to findings from previous assessments were conducted. The relative risk of various demographic, occupational, and health factors on psychological distress was also examined. **RESULTS:** Self-reported sources of occupational stress are similar to those reported in previous assessments of this population. Approximately 20-25% of DCGS operators reported high psychological distress, a modest increase from previous assessments. With respect to operational risk factors, high role overload and role conflict were associated with greater risk of psychological distress. Low professional efficacy and low job satisfaction also emerged as operational risk factors, as did high levels of exhaustion and cynicism. When reviewing personal risk factors, operators endorsing relationship difficulties with a significant other, chronic inadequate sleep, and increased caffeine, alcohol, or tobacco use had an increased risk for psychological distress. **DISCUSSION:** The descriptive nature of this study can

increase awareness among military medical practitioners as to factors that may increase an operator's likelihood of experiencing psychological distress. The results of this study further clarify potential risk factors for negative psychological outcomes among individuals working in the Air Force DCGS community. Interventions designed to mitigate the impact of potential risk factors can be designed to improve the health and well-being of DCGS operators.

Learning Objective

1. The audience will learn of the prevalence of psychological distress for DCGS operators.

[303] DISTRIBUTED COMMON GROUND SYSTEM OPERATORS: PTSD CHECKLIST FOR DSM-5 SYMPTOMS AND POST-TRAUMATIC STRESS DISORDER

Tanya Goodman¹

¹U.S. AIR FORCE SCHOOL OF AEROSPACE MEDICINE, Victoria, TX, USA

(Original Research)

INTRODUCTION: U.S. Air Force distributed common ground system (DCGS) operators experience the combat environment on a day-to-day basis. The relationship between vicarious exposure and post-traumatic stress is particularly important to understand for this community, given their unique "deployed-in-garrison" work environment. The prevalence and expression of post-traumatic stress disorder (PTSD) symptoms are critical to the effective delivery of comprehensive healthcare for this population. **METHODS:** In the current study of 1007 operators, 701 DCGS intelligence (intel) operators were asked if they had experienced an extremely stressful event that they would characterize as traumatic in nature. Those who endorsed this type of event were asked to complete the PTSD Checklist for DSM-5 [Diagnostic and Statistical Manual of Mental Disorders, 5th Edition] (PCL-5). The present study was reviewed and granted exemption by the Air Force Research Laboratory Institutional Review Board at Wright-Patterson Air Force Base and assigned protocol number F-WR-2011-0070-E. The patterns of individual symptom and symptom categories were examined and compared to PTSD findings from previous assessments of the DCGS population. **RESULTS:** A total of 258 DCGS intel operators responded to the PCL-5. Approximately 4% of DCGS intel operators met symptom criteria for PTSD, and 2% had a high rate of symptom expression, indicated by a high score on the PCL-5. Compared to a similar study in 2011, an upward trend of PTSD symptom criteria endorsement was found, but rates were similar to another study of this population in 2016. Operators with PTSD symptom criteria tended to report trouble falling or staying asleep, feeling very upset when something reminded them of the stressful experience, avoiding memories, thoughts, or feelings related to the stressful experience, and feeling distant or cut off from other people. **DISCUSSION:** The results of this study suggest that specific PTSD symptoms and symptom categories are more relevant for DCGS operators than other symptoms. This study provides military practitioners with specific PTSD symptoms to watch for in this unique work environment.

Learning Objective

1. The audience will learn of the PTSD symptoms most commonly reported by DCGS operators.

[304] IMPORTANCE OF UNIT & MEMBER SOCIAL SUPPORT FOR PSYCHOLOGICAL DISTRESS, PTSD & JOB SATISFACTION AMONG DISTRIBUTED COMMON GROUND SYSTEM OPERATORS

Rachael Martinez¹

¹U.S. AIR FORCE SCHOOL OF AEROSPACE MEDICINE, Dayton, OH, USA

(Original Research)

INTRODUCTION: The need to sustain operational situational awareness over long, back-to-back shifts, combined with exposure to extreme levels of combat, results in an extremely stressful work environment that may make distributed common ground system (DCGS) operators particularly susceptible to negative occupational outcomes. Social support from unit members and leaders can play a critical role in the success and general well-being of these individuals, particularly in relation to mitigating psychological distress and post-traumatic stress disorder (PTSD) and enhancing job satisfaction. **METHODS:** The present study included 1007 DCGS intelligence operators who responded to a

comprehensive occupational health assessment. Psychological distress was measured by the Outcome Questionnaire, a 45-item measure assessing difficulties in interpersonal relationships, social roles, and overall quality of life. The PTSD Checklist for DSM-5 [Diagnostic and Statistical Manual of Mental Disorders, 5th Edition], a 20-item measure of PTSD symptoms, was used. Unit social support (member and leader) was measured by the Deployment Risk and Resilience Inventory-2 Social Support Scale, a 12-item subscale. Job satisfaction was measured with a single item on a 0-10 scale. The present study was reviewed and granted exemption by the Air Force Research Laboratory Institutional Review Board at Wright-Patterson Air Force Base and assigned protocol number F-WR-2011-0070-E. Relationships among the measures were examined and, where possible, comparisons to previous assessment findings were made. **RESULTS:** In comparison to a 2016 study of DCGS operators, rates of high psychological distress were moderately higher, and rates of PTSD symptom criteria endorsement and job satisfaction were similar. Higher levels of member and leader social support presented as protective factors against negative stress outcomes, both moderately associated with lower levels of psychological distress and fewer reported PTSD symptoms. In addition, higher levels of member and leader social support were significantly associated with greater job satisfaction. **DISCUSSION:** Findings underscore the importance of member and leader engagement in mitigating the negative psychological outcomes frequently associated with working in the Air Force DCGS community. Interventions designed to promote unit and member social support can be implemented to improve the emotional and social well-being of DCGS operators.

Learning Objective

1. The audience will understand the importance of member and leader engagement for psychological resilience for DCGS operators.

[305] IMPORTANCE OF MORAL AND SPIRITUAL WELL-BEING AMONG DISTRIBUTED COMMON GROUND SYSTEM OPERATORS

Anne Shadle¹, Wayne Chappelle¹

¹U.S. AIR FORCE SCHOOL OF AEROSPACE MEDICINE, Dayton, OH, USA

(Original Research)

INTRODUCTION: High levels of stress have been shown to impact job satisfaction, mental wellness, and overall well-being. U.S. Air Force distributed common ground system (DCGS) operators work in high-stress environments and are exposed to potentially traumatic events that can contribute to anxiety and other mental health problems. This study seeks to determine the impact of high occupational and combat-related stress on moral beliefs, social and emotional functioning, and a sense of purpose in the DCGS community. **METHODS:** DCGS operators were asked to complete an anonymous comprehensive occupational health assessment that included the Outcome Questionnaire 45.2, the PTSD [post-traumatic stress disorder] Checklist for DSM-5 [Diagnostic and Statistical Manual of Mental Disorders, 5th Edition], and questions assessing moral injury. The Spiritual Well-Being Scale was also used in this survey, with particular focus on its subcomponents of existential and religious well-being. The present study was reviewed and granted exemption by the Air Force Research Laboratory Institutional Review Board at Wright-Patterson Air Force Base and assigned protocol number F-WR-2011-0070-E. Responses to the scales were used to identify relationships between indicators of social and emotional functioning as they relate to aspects of spiritual well-being. **RESULTS:** Rates of high psychological distress were moderately higher than a similar study of DCGS operators from 2016. Rates of PTSD symptom criteria endorsement were similar to the 2016 study. Intelligence operators who endorsed high existential well-being were less likely to endorse high levels of psychological stress and PTSD symptom criteria. Those with high existential well-being were also less likely to report feeling that their moral beliefs had been violated by their experiences with remote combat or combat support. **DISCUSSION:** Existential well-being appears to contribute to psychological resilience for DCGS intelligence operators. This suggests that life satisfaction and sense of purpose are related to more positive stress coping capabilities and the ability to better manage reactions to combat experiences. Mental wellness is an important component of overall health and is essential for remote warriors to effectively carry out their mission. Future research should examine the impact of interventions and education that are focused on increasing existential well-being and how this impacts psychological resiliency.

Learning Objective

1. The audience will understand the importance of spiritual well-being for psychological resilience for DCGS operators.

[306] POSITIVE AND NEGATIVE COPING STRATEGIES FOR PSYCHOLOGICAL DISTRESS AND POST-TRAUMATIC STRESS DISORDER AMONG DISTRIBUTED COMMON GROUND SYSTEM OPERATORS

Kinsey Bryant-Lees¹

¹U.S. AIR FORCE SCHOOL OF AEROSPACE MEDICINE, Alexandria, VA, USA

(Original Research)

INTRODUCTION: U.S. Air Force (USAF) distributed common ground system (DCGS) operators have higher rates of psychological distress and post-traumatic stress disorder (PTSD) than other mission areas in the USAF. Understanding both the positive and negative coping strategies employed by DCGS intelligence (intel) operators is critical to the effective delivery of mental healthcare of this population. **METHODS:** DCGS intel operators responded to a comprehensive occupational health assessment that included questions on demographics, occupational factors, stress outcomes, and health behaviors. The Outcome Questionnaire was used to assess psychological distress. The PTSD Checklist for DSM-5 [Diagnostic and Statistical Manual of Mental Disorders, 5th Edition] was used to assess PTSD symptom criteria. The present study was reviewed and granted exemption by the Air Force Research Laboratory Institutional Review Board at Wright-Patterson Air Force Base and assigned protocol number F-WR-2011-0070-E. Relative risks for high psychological distress and PTSD symptom criteria were run. Demographic, occupational, and health behavior patterns of those reporting low psychological distress and low symptom criteria were also examined. **RESULTS:** Positive health behaviors included sleeping 7 or more hours per night and engaging in aerobic exercise three or more days a week. These results are consistent with the most commonly self-reported stress coping strategies: exercise, sleep, leisure/recreational activities, and personal time. Additionally, when examining individuals who presented low psychological distress and few PTSD symptoms, this population also tended to reflect healthier utilization rates of alcohol, caffeine, and tobacco products. Negative health behaviors for PTSD symptom criteria were similar to those reported for high psychological distress in the current study and in previous assessments of this population. These negative health behaviors included inadequate sleep, minimal exercise, and elevated use of stimulants and alcohol. **DISCUSSION:** These findings highlight the importance of consistent sleep and exercise and moderate use of alcohol and various caffeine and nicotine-based products among individuals working in the USAF DCGS community. Interventions designed to promote better sleep, exercise, and other healthy lifestyle habits should be implemented to improve the health and well-being of DCGS operators.

Learning Objective

1. The audience will hear the importance of healthy sleep and exercise routines, in addition to other healthy lifestyle habits in relation to negative stress outcomes.

Wednesday, 05/20/2020

2:00 PM

Centennial II

[S-61]: SLIDE: SELECTION FOR U.S. UNIFORMED SERVICES AND SPECIAL DUTY

Chair: Richard Bachmann

Co-Chair: Joe Ortega

[307] DEPARTMENT OF DEFENSE MEDICAL EXAMINATION REVIEW BOARD OVERVIEW: HISTORY AND CURRENT STATE OF MILITARY OFFICER APPLICANT MEDICAL SCREENING

Lawrence Mullen¹, Glenn Dowling¹

¹Defense Health Agency, Colorado Springs, CO, USA

(Education - Program / Process Review Proposal)

The Department of Defense Medical Examination Board (DoDMERB), established in 1972 as SACMERB (Service Academy Medical Examination Review Board) conducts initial medical screening evaluations for approximately 95% of applicants to commissioning programs of the U.S. Uniformed Services, to include all five Service Academies, all Reserve Officer Training Corps programs, the Uniformed Services University of the Health Sciences, the U.S. Public Health Service, and other programs as assigned by the Assistant Secretary of Defense for Health Affairs. For the armed services, the overwhelming majority officers going on to flight training arise from this screening pool. The DoD's Accession Medical Screening Working Group (AMSWG) developed and periodically updates the medical screening standards for accession leveraged by DODMERB, as well as the US Military Entrance Processing Command (USMEPCOM). This presentation will review the history of DODMERB, the AMSWG, and the evolution of initial medical screening standards for military service. The presenter will provide an overview of the current initial medical screening process for officer program applicants. And finally, the presenter will discuss significant policy changes influencing the what, how, and why of the initial medical screening process for officer applicants to uniformed commissioning programs.

Learning Objectives

1. Identify the primary reason for establishing the AMSWG.
2. Understand the purpose of establishing SACMERB, which later evolved into DoDMERB
3. Understand the relationship between the AMSWG and MedPers

[308] TOP MEDICAL DISQUALIFIERS OF UNIFORMED SERVICE COMMISSIONING PROGRAMS

William Mann¹, Glenn Dowling¹, Kenneth Kuhn¹, Michael Rappa¹, Ernest Sullivent², Ethan Bertsch¹, Maureen Califf³, Breanna Hennager³

¹Defense Health Agency, Colorado Springs, CO, USA; ²Public Health Service, Colorado Springs, CO, USA; ³MITRE Corp, Colorado Springs, CO, USA

(Education - Program / Process Review Proposal)

The Department of Defense Medical Examination Board (DoDMERB), a division of the Defense Health Agency, conducts medical screening evaluations and determines medical qualification (Q) or disqualification (DQ) for approximately 95% of applicants to commissioning programs of the U.S. Uniformed Services, to include all five Service Academies, all Reserve Officer Training Corps programs, the Uniformed Services University of the Health Sciences, the U.S. Public Health Service, and other programs as assigned by the Assistant Secretary of Defense for Health Affairs. For the armed services, the overwhelming majority officers going on to flight training arise from this screening pool. Department of Defense Instruction 6130.03, "Medical Standards for Appointment, Enlistment, or Induction into the Military Services," provides the framework and standards for Q/DQ decisions. For the years 2015-2018, DoDMERB processed well over 160,000 commissioning program applications and applied tens of thousands of DQ's for myriad conditions. The presenter will describe the most common disqualifying conditions. Discussion will include criteria for Q/DQ, differences in disqualifying conditions by commissioning program and year group, and final disposition as manifest by waiver approval or denial by condition and commissioning program.

Learning Objectives

1. Identify the most frequently applied medical disqualifiers for U.S. Uniformed Service Commissioning Programs
2. Understand the criteria associated with the most frequently applied medical disqualifiers
3. Understand rates at which medical waivers are granted for the most frequently applied medical disqualifiers by commissioning program

[309] MILITARY OFFICER ACCESSION MEDICAL SCREENING CASE STUDIES

Michael Rappa¹, Glenn Dowling¹, William Mann¹, Kenneth Kuhn¹, Lawrence Mullen¹, Ernest Sullivent²

¹Defense Health Agency, Colorado Springs, CO, USA; ²Public Health Service, Colorado Springs, CO, USA

(Education - Case Study: Clinical / Human Performance)

The Department of Defense Medical Examination Board (DoDMERB) conducts initial medical screening evaluations for approximately 95% of applicants to commissioning programs of the U.S. Uniformed Services, to include all five Service Academies, all Reserve Officer Training Corps programs, the Uniformed Services University of the Health Sciences, the U.S. Public Health Service, and other programs as assigned by the Assistant Secretary of Defense for Health Affairs. For the armed services, the overwhelming majority officers going on to flight training arise from this screening pool. The DODMERB Physician presenter will highlight 5-6 deidentified military officer accession medical screening cases that illustrate the complexities and nuance of qualification/disqualification decision making. Emphasis will be placed on clinician interpretation of accession standards, characterization of risk, leveraging external clinical resources, and outcome objectives as they pertain to the many different officer accession programs supported by DODMERB. The presentation is intended to be interactive with Q&A and follow-up discussion with the DODMERB physician presenter and the DODMERB Deputy Division Chief.

Learning Objectives

1. Identify 3 elements of risk to the Department of Defense in accession medical screening practice.
2. Become familiarized with the pros and cons of clinician discretion in interpretation of accession medical standards.
3. Articulate differences between medical screening for disqualifying conditions versus diagnosis of conditions that are disqualifying.

[310] ISAAC JONES MD - RETRACING THE FIRST AVIATION MEDICAL EXAMINATIONS

Charles Fisher¹

¹AvMED Consultants (sole proprietor - me), San Antonio, TX, USA

(Education - Program / Process Review Proposal)

BACKGROUND: The theme for this AsMA scientific forum revolves around Medical Standards for Aviation and Space Medicine. The heritage of today's physical examinations process world-wide, can in large part be traced to Isaac Jones MD who in a matter of months developed tools, techniques and guidance for examinations, travelled around the nation, trained hundreds of physicians and staff members, and with their help executed over ten thousand examinations in an age before high speed communications. **OVERVIEW:** This is a historical review, using contemporary news reports and eyewitness accounts of Dr. Jones amazing nationwide journey and successful method for performing standardized examinations at multiple locations using nearly all volunteer staff with no knowledge of aviation at all. **DISCUSSION:** Dr. Isaac Jones had explored aviation orientation prior to the outbreak of WWI. The standards he developed, the techniques he taught, and the application of those standards was truly groundbreaking a century ago. Moreover, as this review will illustrate, those earliest physical standards linked directly with subsequent international aviation medical standards, many of which are still in use nearly unaltered over 100 years later. This is an homage to one of Aviation Medicine's greatest pioneers.

Learning Objectives

1. The audience will learn about the primary measures of fitness for aviation in 1917.
2. The audience will learn about the innovative method Dr. Isaac Jones used to establish a nationwide network of examination stations in only a matter of weeks.
3. The audience will learn about the direct relationship between the Aviation Medical standards espoused by Dr. Jones and future international aviation medical standards in use today.

[311] DEVELOPING AND ASSESSING A RADAR VECTORING APTITUDE TEST FOR AIR TRAFFIC CONTROL STUDENTS

Tracy Sanders¹, Susan Schultheis¹, Kerry Hutson¹, Keith Baldwin¹

¹The MITRE Corporation, McLean, VA, USA

(Original Research)

INTRODUCTION: As part of an ongoing effort to improve air traffic controller training efficacy and reduce student failure rates, the Federal Aviation Administration (FAA) needs enhanced tools to predict student success and inform student placement. As radar vectoring is a critical task performed by controllers, the MITRE Corporation developed

a Radar Vectoring Aptitude Test, an interactive, computer-based test to evaluate the aptitudes that support effective radar vectoring in air traffic control operation. **METHOD:** The Radar Vectoring Aptitude Test is composed of four sections, each containing two or three subtests. Section 1 provides training on the test and assesses students' aptitudes for compass use and application, data recognition and application, communication, and vectoring aircraft. Sections 2, 3, and 4 evaluate students' ability to vector aircraft in increasingly complex environments. The test requires approximately three hours to complete. The Radar Vector Aptitude Test was administered via computer to air traffic control students at the start of their training at the FAA Academy at the Mike Monroney Aeronautical Center. These students were then monitored, as normal, throughout the course of their training using internal FAA systems to collect data on their training outcomes. Data were de-identified and provided to MITRE researchers for analyses. **RESULTS:** A linear regression was used to evaluate the relationship between the Radar Vectoring Aptitude Test and final FAA Academy score, yielding a significant model [$F(1,351) = 206.00, p < .001, R^2 = .370$] that accounted for 37% of the variance in the model. This indicates a significant predictive relationship between the Radar Vectoring Aptitude Test and FAA Academy score. **DISCUSSION:** These results suggest the Radar Vectoring Aptitude Test may have value as a predictor of trainee performance during initial training. Further research will focus on evaluating opportunities to leverage the test as a placement and training tool. Approved for Public Release; Distribution Unlimited. Public Release Case Number 19-3361. This work was produced for the U.S. Government under Contract DTFAWA-10-C-00080 and is subject to Federal Aviation Administration Acquisition Management System Clause 3.5-13, Rights In Data-General, Alt. III and Alt. IV (Oct. 1996). ©2019 The MITRE Corporation. All rights reserved. The contents of this document reflect the views of the author and The MITRE Corporation and do not necessarily reflect the views of the Federal Aviation Administration (FAA) or the Department of Transportation (DOT). Neither the FAA nor the DOT makes any warranty or guarantee, expressed or implied, concerning the content or accuracy of these views.

Learning Objective

1. The audience will learn about an aptitude test designed to support air traffic controller training.

[312] MAKING MOONSHOTS: AN INVESTIGATION OF SELECTION METHODS FOR PARTICIPATION IN EXPERIMENTAL MILITARY AVIATION TRAINING

Joanna Nelms¹

¹U.S. Air Force, San Antonio, TX, USA

(Education - Program / Process Review Proposal)

BACKGROUND: Pilot Training Next (PTN) is a USAF initiative to revitalize pilot training and learning methods in general within the realm of military training. The moonshot dream of the AETC commander was to take a high school graduate and have them as an F-35 wingman within one year. In a time of pilot shortage and increased need for production, both military and civilian organizations are focusing more on expanded selection methods in order to select the right person for the right airframe in order to maximize force retention and longevity. **OVERVIEW:** As a method of investigating training selection possibilities, 25% of the inaugural class was comprised of enlisted USAF members. These participants were selected with the assistance of a civilian talent recruiting agency, using a conglomerate scoring based largely on cognitive functioning. The second and third iteration enlisted selection processes were broadened and modified to take a more holistic approach, to include looking at personality and motivation objectives. This presentation will initiate a discussion regarding the shortfalls and subsequent effects of selection methods and to address possible courses of action to better select future students drawn from outside the usual pilot training pipeline. **DISCUSSION:** The evaluation and selection efforts made by PTN may directly influence the recruitment and management of human resources in the aviation training pipelines of multiple military and possibly future civilian organizations. We know that cognitive merit alone does not a great aviator make, but the optimal combination of traits are yet to be defined. Further collaboration and investigation is needed in order to better select for retention, performance, and longevity in aviation communities, military and civilian alike.

Learning Objective

1. The audience will learn about lessons learned and experimental selection methods attempted in the setting of a novel aviation training environment.

Wednesday, 05/20/2020
Centennial III

2:00 PM

[S-62]: SLIDE: THE SPACE NEURO-OCULAR CONUNDRUM

Chair: Patrick McGinnis

Co-Chair: James Pavela

[313] COUNTERMEASURES FOR SPACEFLIGHT ASSOCIATED NEURO OCULAR SYNDROME: AN INVESTIGATION OF ARTIFICIAL GRAVITY

Allison Anderson¹, Joseph Butterfield¹, Prem Subramanian²,
Torin Clark¹

¹University of Colorado - Boulder, Boulder, CO, USA; ²University of Colorado - Anschutz Medical Center, Aurora, CO, USA

(Original Research)

INTRODUCTION: The origin of the spaceflight associated neuro-ocular syndrome (SANS) has not been determined conclusively, but long-term exposure to microgravity appears to contribute to ocular changes not present on Earth. Mimicking gravitational loading through artificial gravity (AG) may mitigate these negative adaptations. In our prior work we performed an experiment to investigate two AG conditions. We briefly review these results and identify alternative mechanisms that may affect intraocular pressure (IOP) during AG. **METHODS:** Seventeen subjects (9M, 8F, 18-32 years) completed the experiment. Experimental conditions were: 1) Supine, 2) Standing, 3) center of rotation at the eye (ECAG), 4) 2G's at the feet (2GAG, causing the eye to be off the center of rotation). In both AG conditions, subjects were spun to produce 1G at their center of mass. Data collected included self-administered intraocular pressure (IOP, Tonopen AVIA), and cardiovascular parameters. **RESULTS:** IOP showed a main effect ($F(3,48)=11.0, p<0.0005$), with Standing significantly lower than Supine ($p=0.0009$), AGECE ($p=0.002$), and AG2G (0.036). Supine, AGECE, and AG2G were not statistically different. Cardiovascular parameters were lower in Supine compared to all other postures ($p=0.002$ to $p<0.0005$), but there were no differences between Standing, AGECE, and AG2G. **DISCUSSION:** Cardiovascular parameters behaved as hypothesized, as did IOP in the supine and standing positions. In both AG conditions, though, IOP was elevated above standing values. Since IOP is driven by cardiovascular parameters and fluid shift, this is contrary to the initial hypothesis. This indicates there are additional unconsidered factors influencing IOP in AG. We propose that either venous pressures were elevated or choroidal blood volume was increased in AG beyond what was expected. Potential mechanisms include systemic vasoconstriction in the legs, enhanced venous return due to leg muscles, increased thoracic pressures due to tissue weight, and/or elevated choroidal blood flow. These mechanisms are being evaluated through a series of experiments. This study was the first to investigate IOP during short radius centrifugation, informing its use as a proposed countermeasure to mitigate SANS. Our results inform the potential for future designs of AG systems in microgravity, which will likely be an intermittent, short-term exposure of centrifugation.

Learning Objectives

1. Participants will understand the potential utility of artificial gravity to mitigate the spaceflight associated neuro-ocular syndrome.
2. Participants will know how intraocular pressure changes with changes in posture and artificial gravity.
3. Participants will understand potential alternative contributing factors to IOP in AG.

[314] ACUTE EFFECTS OF POSTURAL CHANGES AND LOWER BODY POSITIVE AND NEGATIVE PRESSURE ON THE EYEMichael Van Akin¹, Abigail Fellows², Olivia Lantz², Jay Buckley², Allison Anderson¹¹University of Colorado Boulder, Boulder, CO, USA; ²Dartmouth College, Lebanon, NH, USA*(Original Research)*

INTRODUCTION: Spaceflight Associated Neuro-ocular Syndrome (SANS) occurs exclusively during long-duration spaceflight. The pathophysiology is unknown, so using terrestrial analogues to develop an understanding of possible mechanisms is highly desirable. The removal of hydrostatic gradients and cephalad fluid shift in microgravity have been hypothesized as contributing factors. Postural changes (supine/prone) can alter hydrostatic gradients and lower body negative pressure (LBNP) or positive pressure (LBPP) can produce fluid shifts, allowing for these effects on the eye to be studied on Earth. **METHODS:** Ocular measurements were recorded for 15 subjects (7 male, 8 female). The measurements were recorded seated (baseline), supine, prone with 40mmHg LBNP, prone with 40 mmHg LBPP, supine with 40mmHg LBNP, and supine with LBPP to 40mmHg. Perifoveal choroidal thickness from Heidelberg Spectralis Optical Coherence Tomography (OCT) raster scans, absolute minimum rim width (MRW) from OCT glaucoma scans, and IOP from a Perkins Tonometer were measured. A linear mixed-effects model analysis was performed to determine the effects of posture and fluid shift interventions. **RESULTS:** All postures and interventions increased IOP relative to seated baseline ($p < 0.01$) except supine with 40mmHg LBNP, which did not significantly change IOP relative to seated baseline. IOP increased from a seated baseline of 14.6 ± 3.0 mmHg to 16.4 ± 3.0 mmHg in the supine posture and to 23.9 ± 4.7 mmHg in the prone posture. LBPP increased the mean IOP and LBNP decreased the mean IOP in each posture. Perifoveal choroidal thickness and absolute MRW did not change acutely across postures and interventions (choroid: all $p > 0.07$ | MRW: all $p > 0.17$). **DISCUSSION:** The IOP results from the supine with 40mmHg LBNP condition are consistent with the anticipated combined, opposite effects of a hydrostatic gradient at the posterior part of the eye and a fluid shift away from the head. Choroidal thickness did not change even though previous studies have shown choroid thickness changes on timescales shorter than the posture and intervention times from this study. Future analysis will also investigate changes to temporal-superior-nasal-inferior-temporal graphs of MRW, which may be more sensitive than absolute MRW. Comparing the acute changes in choroid thickness, MRW, and IOP from terrestrial analogs to microgravity can help understand SANS.

Learning Objective

1. Understand the acute effects of posture and LBPP/LBNP on the eye and how these relate to developing an understanding of the pathology of SANS.

[315] ASTRONAUT OPHTHALMIC FINDINGS ARE RELATED TO OPTIC NERVE LENGTH CHANGES BUT NOT BRAIN MOVEMENTJay Buckley¹, Anders Wåhlin², Petter Holmlund², Abigail Fellows¹, Jan Malm², Anders Eklund²¹Geisel School of Medicine at Dartmouth, Lebanon, NH, USA; ²Umeå University, Umeå, Sweden*(Original Research)*

INTRODUCTION: Long-duration spaceflight is associated with changes in visual acuity due in part to globe flattening. To understand the forces responsible for such flattening we measured pre- to post-spaceflight changes in the optic nerve from MRIs. **METHODS:** In 22 astronauts, we co-registered pre- and post-spaceflight MRIs and generated centerline representations of the optic nerve to measure changes in optic nerve length and potential displacements of the optic nerve head and optic chiasm. The changes of the optic nerve were examined in relation to spaceflight duration, physiological baseline parameters, as well as manifestations of Spaceflight-Associated Neuro-ocular Syndrome (SANS). **RESULTS:** We observed an elongation of the optic nerve, as well as an anterior displacement of the optic nerve head. Consistent with previous observations of brain movement post mission, we also measured a

significant superior displacement of the optic chiasm. The optic nerve head displacement was significantly related to mission duration (short vs. long), was greater in those with clinical manifestations, and correlated with overall optic nerve elongation. Conversely, optic chiasm displacement was not related to any of those factors. Interestingly, optic nerve head, but not optic chiasm, displacement was significantly positively related to pre-flight body weight. **DISCUSSION:** Optic nerve head anterior displacement, indicative of an altered pressure gradient across the brain-eye interface, is related to astronaut ocular changes. Optic chiasm displacement, indicative of superior brain movement, is not. These findings are consistent with a mechanism where either increased pressure on the intracranial side, reduced pressure on the intraocular side, or a combination of both exerts a force on the posterior globe potentially leading to remodeling of the globe/optic nerve interface over time.

Learning Objective

1. The audience will learn how the optic nerve length changes measured after spaceflight provide information on how the eye changes in space.

[316] PHYSIOLOGICAL SHIFT OF BRAIN AND OPTIC CHIASM BY BODY POSITION CHANGEShigeto Hayashi¹, Koshi Yokota², Etsuko Kumamoto³, Takashi Sasayama⁴, Eiji Kohmura⁴, Ari Shinjima⁵¹Hyogo Emergency Medical Center/Japanese Red Cross Kobe Hospital, Kobe, Japan; ²Japan Aerospace Exploration Agency, Tsukuba, Japan;³Kobe University Information and Science Technology Center, Kobe, Japan; ⁴Kobe University Graduate School of Medicine, Kobe, Japan;⁵Keio University School of Medicine, Tokyo, Japan*(Original Research)*

INTRODUCTION: Physiological brain shifting in the closed skull has not been analyzed extensively, while the brain shift phenomenon during craniotomy has been described in many reports. In a recent report on a magnetic resonance imaging (MRI) comparison of astronauts who spent about 6 months in space with those spent about 2 weeks, the narrowing central sulcus and the upward shift of the brain occurred more in long-stay astronauts than in short-stay astronauts. Recent studies have suggested that spaceflight-associated neuro-ocular syndrome (SANS), which has also been detected in some astronauts, is attributable to the upward shift of the brain. We used MR images to measure infinitesimal positional changes of the brain and optic chiasm associated with body position changes during normal rest and attempted quantitative and statistical analysis. **METHODS:** A 3.0T MRI was used to obtain 3D fast-spin-echo head MR images of nine healthy volunteers (aged 22–51 years; 5 men and 4 women). For all subjects, images were taken in supine, prone, and left and right lateral positions. 3D image registration was performed based on the inner ear structure as a reference. The brain tissue shifting was measured using a block matching method. The Steel-Dwass multiple comparison test was used to examine the similarity among subjects in shifts of different sites in the surface layer of the brain, the deep brain, and the optic chiasm.

RESULTS: The average shift size of brain tissue were less than 1mm. In left and right lateral positions, virtually no individual differences were found in shift sizes in many sites. In body position changes between supine and prone positions, individual variations in the shift size were large for certain sites, suggesting some degree of freedom in brain shifting. In both body position changes, the surface layer and deep part of the brain tended to behave differently, and the individual similarities in the shift size in the deep brain tended to be greater than those in the surface parts. Individual differences in shifting associated with body position changes were also prominent in the optic chiasm. **DISCUSSION:** Changes in the position and shape of the brain and optic chiasm associated with body position changes under a physiological setting are negligible, but they behave differently depending on the site and between individuals. Positional shifting and deformation of the brain may provide new perspectives for elucidation of pathophysiology.

Learning Objective

1. The audience will learn that the brain parenchyma and optic chiasm changes in the position and shape in association with body position changes under a physiological setting and behave differently depending on the site and between individuals.

[317] CAN CHANGES IN REFRACTION DURING 60 DAYS OF -6° HEADDOWN TILT BED REST PREDICT OPTIC DISC EDEMA?

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(Original Research)

INTRODUCTION: Spaceflight associated Neuro-ocular Syndrome (SANS) describes several ocular changes that can appear in astronauts. One of these changes, is globe flattening in association with a hyperopic shift. To precisely measure the length of the globe, examinations by optical biometry are performed pre- and immediately postflight. During a 30-day bed rest study, with increased CO₂ (0.5%) and a strict -6° head down tilt position without pillows, we observed optic disc edema for the first time in bed rest. The question arose as to whether we could also observe globe flattening and what possibilities exist to potentially recognize these changes in long-duration missions. **METHODS:** 12 test subjects took part in the first campaign of the 60 day, -6° head down tilt AGBRESA study. The length of the eye was measured by an IOL Master. In addition, objective refraction in cycloplegia was also measured pre and post bed rest by an autorefractor. A different and easy way to determine changes in refraction is to perform subjective refraction measurements. To objectify the subjective information, objective measurements of the refraction were also performed for the first time in bed rest studies.

RESULTS: Out of the 12 test subjects, 5 developed optic disc edema. Mean axial length increased from pre to post bed rest (23.87 to 23.92 mm), which was confirmed by a negative increase in objective refraction from -0.44 to -0.57 diopters (spherical equivalent). Mean subjective refraction decreased from 0.15 to 0.11 diopters from head down tilt (HDT) day 15 to 58. However, mean subjective refraction in cases with optic disc edema became more positive from -0.05 to +0.15 diopters from HDT day 15 to 58.

DISCUSSION: Axial length increased during the study, which was confirmed by an increase in the negative objective refraction. These findings suggest that measurement of objective refraction in cycloplegia is useful for excluding hyperopic shift from globe flattening. However, the increase in eye globe length is contrary to the globe changes observed in astronauts. Furthermore, there is a subjective hyperopic shift in the subjective refraction of test subjects with optic disc edema, which probably comes from retinal thickening that is not measured by the IOL Master biometry system, which refers to the retinal pigment epithelium. Altogether, subjective refraction may be an easy and efficient method to screen for optic disc edema during deep space exploration.

Learning Objective

1. The audience will learn about the changes in refraction during head down tilt bed rest studies also in relation to optic disc edema.

[318] EXERCISE INDUCED CHANGES IN ARTERIAL AND INTRACRANIAL PRESSURE

Lonnie Petersen¹, Evan Grave¹, Justin Lee¹, Marianne Juhler², Alexander Lilja-Cyron², Johan Petersen¹

¹University of California, San Diego, La Jolla, CA, USA; ²University of Copenhagen, Copenhagen, Denmark

(Original Research)

INTRODUCTION: Exercise is the primary countermeasure during spaceflight. While benefits are apparent, exercise induced increases in blood pressure have been suggested to elevate intracranial pressure (ICP) and aggravate neuro- and ocular changes associated with long-duration missions. We tested the hypothesis that moderate aerobic exercise does not significantly increase ICP and the well described post-exercise arterial hypotension is reflected in a concomitant decrease in ICP thereby maintaining cerebral perfusion pressure (CPP). **METHODS:** After 15 min supine rest 16 volunteers (8 female) completed 30 min upright seated aerobic ergonomic bicycle exercise at 70% heart rate reserve by Karvonen formula ($HR = 70\% * (HR_{max} - HR_{rest}) / HR_{rest}$) followed by a 1 hour supine rest period. In 13 subjects ICP was estimated non-invasively (CCFP, Marchbanks Systems). In 3 subjects parenchymal ICP was directly measured through a frontal burr hole (Neurovent-P, Raumedic). In all continuous cardiovascular profile was recorded (Nexfin). **RESULTS:** Invasive and non-invasive ICP changes were correlated ($R^2=0.90$, $P<0.001$) and thus combined. Compared

to supine baseline, post-exercise supine ICP was $53 \pm 19\%$ lower ($P<0.0001$) and gradually returned to baseline values 30 min after exercise ($P=0.098$). This trend was correlated to MAP ($R^2=0.81$, $P=0.006$), which initially decreased (from 83.9 ± 2.4 to 76.6 ± 2.9 mmHg) and returned to baseline approx. 30 min after exercise. Underlying vasodilation of exercised muscles and reduced venous return were reflected by lower total peripheral resistance and stroke volume, both correlated to the drop in ICP ($R^2=0.90$, $P=0.001$ and $R^2=0.68$, $P=0.022$, respectively). Heart rate was increased during and after exercise ($P<0.05$). CPP was maintained throughout the supine recovery ($P=0.1$). In 3 subjects, ICP was directly recorded during exercise, which did not increase ICP (seated rest baseline: -4 ± 4 mmHg, avg of 30 min aerobic exercise: -5 ± 3.5 mmHg).

DISCUSSION: Post-exercise arterial hypotension was mirrored in ICP thus maintaining CPP. Our data do not indicate that a moderate aerobic exercise-countermeasure significantly drives up ICP. Moreover, post exercise vasodilation and hypotension trends to reduce ICP, which could be beneficial. Our data is limited by small N which was insufficient to reveal gender or age differences. Although speculative, attenuated concomitant decrease in ICP could impair CPP and induce terrestrial/clinical post-exercise syncope

Learning Objective

1. To understand the effects of aerobic exercise on arterial and intracranial pressure and add input to the debate regarding the role of exercise in either aggravating or ameliorating neuro and ocular changes associated with long duration spaceflight.

[S-63] AAMIMO CASES--see AEROSPACE MEDICINE RESIDENTS GRAND ROUNDS PARTS I & II

Wednesday, 05/20/2020
 Regency 6

2:00 PM

[S-64]: SLIDE: AVIATION ACCIDENT & INJURY MITIGATION

Chair: Douglas Boyd

Co-Chair: Phillipe Souvestre

[320] ACCIDENT RATES, CAUSES AND OCCUPANT INJURY SEVERITY INVOLVING HIGH-PERFORMANCE GENERAL AVIATION AIRCRAFT

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(Original Research)

INTRODUCTION: Spatial disorientation/poor situational awareness/ aerodynamic stalls are often causal/contributory to general aviation accidents. To mitigate against the occurrence of these mishaps Cirrus Aircraft has, since 2002, introduced advanced avionics into their piston airplanes (Cirrus SR20/22). These airplanes are also certificated to more rigorous crashworthiness tests than legacy aircraft approved prior to these standards being codified. Herein, using for comparison two legacy aircraft fleets manufactured ≤ 2001 and the aggregate general aviation fleet, we determined whether a (i) reduced mishap rate relating to the aforementioned causes/contributing factors (ii) diminished injury severity for survivable accidents were evident for Cirrus SR20/22 airplanes.

METHODS: Accidents (2008-2017) involving Cirrus SR20/22 airplanes (manufactured ≥ 2002), Beechcraft 35/36 (Bonanza) and Mooney 20 models (both manufactured ≤ 2001) operating under 14CFR Part 91 rules were per the NTSB database. Statistical tests included Poisson distribution (rate changes), contingency tables (proportional differences) and T- and Mann-Whitney tests (averages and medians respectively). **RESULTS:** For each year within the 2013-2017 timespan the Cirrus SR20/22 all-accident rate was diminished 39-75% relative to both legacy aircraft fleets. While the all-injury accident rate only trended ($p=0.520$) lower for the former, it progressively rose for Mooney aircraft ($p=0.007$). Temporally, the fraction of fatal Cirrus SR20/22 accidents declined 50% achieving a lower ($p=0.038$) or comparable proportion to the two legacy airframes. The

fraction of fatal accidents for Cirrus SR20/22 airplanes was higher ($p=0.001$) than that of the general aviation aggregate fleet across the decade although controlling for time, the proportion of lethal accidents for the two cohorts were statistically unchanged (0.20 and 0.16; $p=0.537$) for the most recent years (2014-2017). Fatal accident rates involving spatial disorientation/situational awareness/ aerodynamic stalls were >80% lower for Cirrus SR20/22 airplanes. For survivable mishaps, Cirrus SR20/22 aircraft showed a lower proportion (0.13 compared with 0.20-0.35) of fatal/serious injuries ($p=0.021$). **DISCUSSION:** Towards improving legacy aircraft safety, owners should be encouraged to (i) upgrade their avionics for mitigating against the occurrence of such human-factor-related mishaps (ii) install airbags to minimize injury severity.

Learning Objectives

1. The audience will learn of the substantially higher accident rate for general aviation compared with commercial operations with most due to pilot error rather than equipment failure/malfunction.
2. The role of new (to general aviation) technologies for mitigating against the occurrence of common aerospace medicine-human factor (e.g. spatial disorientation, diverted pilot's attention/distractions, poor situational awareness) accidents will be made.
3. The audience will learn about the efficacy of the revised crashworthiness standards in reducing injury severity in survivable general aviation accidents.

[321] CHARACTERIZATION OF FATAL INJURIES IN OIL AND GAS INDUSTRY-RELATED HELICOPTER ACCIDENTS IN THE GULF OF MEXICO, 2004–2014

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²Centers for Disease Control and Prevention, Spokane, WA, USA;

³University of Virginia, Charlottesville, VA, USA

(Original Research)

INTRODUCTION: Helicopter crashes contribute to high fatality rates in the oil and gas industry. Previous research has focused on the underlying causes of crashes or aircraft structure and design rather than on the injuries sustained in crashes. Helicopter operators in the Gulf of Mexico promote robust aviation safety programs, yet fatalities continue to occur in crashes considered survivable, and despite high safety standards. **METHODS:** Accident reports from the National Transportation Safety Board's Aviation Accident database were reviewed manually for helicopter accidents occurring in the Gulf of Mexico in support of the oil and gas industry and resulting in at least one fatality from crash-related injuries. Autopsy reports were requested, reviewed, and coded using the Abbreviated Injury Scale. A descriptive analysis of injury distributions was performed. **RESULTS:** Fourteen fatal helicopter accidents resulting in 42 fatalities met the study criteria. Autopsies were conducted on 35 decedents with 568 injuries documented, with a median of 12 injuries per decedent and a range of 1–44 injuries. The proportion of minor, moderate, and severe or worse injuries differed by body region. Minor injuries were most prevalent in the face, neck, upper and lower extremities, and abdomen. **DISCUSSION:** Further research is needed to better understand the highest priority injuries on which to focus engineering and safety designs. Findings suggest further evaluation of airbag restraint systems to decrease torso and extremity injuries, helmets to decrease head injuries, and egress training and supplemental breathing devices to prevent drownings are warranted.

Learning Objectives

1. The participant will obtain an understanding of the severity and body region frequencies for injuries incurred by pilots and passengers during fatal oil and gas-related helicopter accidents in the Gulf of Mexico.
2. The participant will learn the similarities and differences in severity and body regions between injuries among drowning and non-drowning victims and potential prevention strategies.

[322] IMPACT OF DAYLIGHT SAVINGS TIME ON AIRCRAFT ACCIDENT RATE IN THE USA

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(Original Research)

BACKGROUND: Each year, clocks in the USA (US) move forward one hour in the spring for daylight savings time (DST), thus decreasing sleep by one hour on the day of the switch. There is conflicting data in the literature as to whether this decrease in sleep affects the motor vehicle collision rate. There has been no study thus far on the effects of the change on the aircraft accident rate. **METHODS:** The National Transportation Safety Board (NTSB) Database was queried for all aircraft accidents and incidents in the US between January 1, 2000– October 30, 2019. Rates of Fatal Accidents (FA), Nonfatal Accidents (NA), and Incidents (I) were compared between 2000-2009 and 2010-2019. The daily rate of FA, NA, and I were compared between the 2 days after the DST change and March and April overall. Total yearly and monthly flight data, and in the days after the DST change were queried from the Federal Aviation Administration (FAA) Air Traffic Activity System (ATADS). All comparisons were done with unpaired T-Test. **RESULTS:** The average rate, per million flights, of fatal accidents (7.4 ± 0.7 to 5.9 ± 0.08 , $p<0.001$), nonfatal accidents (32.0 ± 2.2 to 26.9 ± 2.9 , $p<0.001$), and incidents (1.2 ± 0.3 to 0.8 ± 0.6 , $p=0.04$) all declined significantly from 2000-2009 to 2010-2019. There was a significant decrease in the average yearly number of flights from 2000-2009 to 2010-2019 ($45.0 \times 10^6 \pm 2.2 \times 10^6$ to $41.2 \times 10^6 \pm 3.3 \times 10^6$, $p=0.007$). There was no significant difference between the daily rate of fatal or nonfatal accidents, or incidents per million flights between the 2 days after the DST change and the remainder of March and April (4.9 ± 4.6 vs 5.5 ± 1.1 , $p=0.583$; 25.0 ± 12.0 vs 27.1 ± 4.5 , $p=0.476$; 0.6 ± 1.5 vs 1.6 ± 0.7 , $p=0.134$, respectively). There was no significant difference in the daily average number of flights between the 2 days after the DST change and the rest of March and April ($122,190 \pm 6714$ vs $123,444 \pm 8343$, $p=0.604$).

DISCUSSION: Despite a decrease in total number of flights, the overall rate of aircraft accidents, both fatal and nonfatal, and incidents has declined significantly over the last two decades. The loss of one hour of sleep from the DST change does not appear to affect the accident rate in the following days. Since the number of flights on the days after the DST change is not significantly different than the rest of the month, pilots may be self-compensating for less sleep by using other methods to decrease risk.

Learning Objectives

1. The switch to Daylight Savings Time does not affect the aircraft accident rate.
2. The aircraft accident rate has declined in the last 20 years.

[323] ASSESSMENT OF AIRCREW HEAD INJURY PROTECTION AFTER HELMET LINER MODIFICATIONS

Jonathan Calderon¹, Greg Ganz¹, Shelby Sous¹, Jodie Gomez¹, Katie Logsdon¹, Frederick Brozowski¹

¹U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA

(Original Research)

INTRODUCTION: U.S. Army aviators who have difficulties obtaining a comfortable helmet fit, usually with an atypical head anthropometry, are referred to the U.S. Army Aeromedical Research Laboratory Problem Fit (USAARL PROFIT) program by their aviation life support equipment technicians. USAARL PROFIT personnel make minor modifications to the comfort liner. The resulting effects are unknown on blunt impact performance capabilities of the HGU-56/P Aircrew Integrated Helmet System (AIHS) and head injury protection. It is important these effects are quantified and the risks associated with modifications are understood by the USAARL PROFIT personnel, the aviator, and the aviator's chain of command. **METHODS:** Two approved liners were selected for evaluation through an audit of the PROFIT records: Super Comfort Liner™ (SCL) and Thermal Plastic Liner® (TPL). We removed the two inner-most layers of the thermoplastic material for each liner. Helmets were tested according to HGU-56/P AIHS Purchase Description (DOD, 1996) on a monorail drop tower (ANSI, 1966). The monorail drop tower was instrumented to collect three channels of data: Impact velocity, headform acceleration, and impact force. The helmet's blunt impact performance was assessed using the peak headform acceleration for each impact. The effects of helmet liner modification were evaluated in a sequence of tests. Part one tested 6 helmets each of the modified SCL™ and modified TPL® in the hot environmental condition. Part two tested 6 helmets with the modified TPL® in the ambient condition. **RESULTS:** Part one: modified SCL™ helmets recorded average peak headform accelerations of $112.51G$ ($SD=4.49$) at the crown

and 141.63G (SD=10.30) at the headband locations. The modified TPL® helmets with recorded average peak headform accelerations of 112.69G (SD=3.78) at the crown and 144.71G (SD=17.45) at the headband locations. Part two: modified TPL® helmets recorded average peak headform accelerations of 124.16G (SD=5.14) at the crown and 148.65G (SD=9.23) at the headband locations. **DISCUSSION:** Data collected indicated the removal of the two inner-most layers of either the SCL™ or TPL® does not degrade the blunt impact protection of the helmet below that of the pass-fail head acceleration threshold of 150 and 175G for crown and headband locations, respectively. One helmet in part two did fail on a rear impact. Several factors could contribute to this failure including helmet orientation and liner installation.

Learning Objectives

1. Understand the need for the helmet fitting systems to improve aircrew helmet stability, retention and wearer comfort.
2. Learn the effects of heat on blunt impact protection.
3. Learn the variation in blunt impact protection across common helmet liners (SCL vs TPL).

[324] ANALYSIS OF POST EJECTION SPINAL INJURIES IN INDIAN AIR FORCE FROM 1998 TO 2012

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¹Institute of Aerospace Medicine, IAF, Bangalore, India; ²Indian Air Force, Bangalore, India

(Original Research)

BACKGROUND: In Indian Air Force, ejection injuries have been studied at different periods of time from 1957 to 1998. The reported incidence of fatal ejection injuries vary from 3.2% to 28.6%. Similarly, the serious spinal injuries have been reported to be between 26.2% to 41%. No studies were done since 1998. The present study was conducted to analyze the ejection spinal injuries from 1998 to 2012 to understand the changes in the injury pattern and trend over the years. **METHODS:** Completed forms of 'Medical Report on A Major Aircraft Accident I.A.F.F (MS) 1956' on all ejections from 1998 to 2012 held at the Department of Human Engineering and Department of Pathology & Toxicology were used for collection of data. The data were analyzed to find out the overall incidence of ejections, type of ejection injuries, nature, location and distribution of ejection injuries. Data were analyzed using descriptive statistical methods.

RESULTS: There were a total of 108 ejections in IAF from 1998-2012. However, the completed forms of 'Medical Report on A Major Aircraft Accident I.A.F.F (MS) 1956' were available for only 56 ejections. Out of these 56 ejections, 47 were non-fatal and 09 were fatal ejections. The overall incidence of spinal injuries is found to be 42.8%. The incidence of spinal injuries in non-fatal ejections is found to be 40.4%. The incidence of spinal injuries in fatal ejections is found to be 55.5%. **CONCLUSION:** In the present study, the spinal injuries were found to be the most common injuries (42.8%). The incidence of spinal injuries is relatively high in this study as compared to the previous studies in Indian Air Force.

Learning Objectives

1. Analysis of the ejection injuries to understand the change in the injury pattern and trend over the years.
2. To study the spinal injury pattern in relation to the type of aircraft, type of ejection seat and various flight parameters at the time of ejection.

[325] A CASE REPORT OF A HAWK AIRCRAFT EJECTION ACCIDENT AND MODELLING OF THE EJECTION SEQUENCE

Matthew Lewis¹

¹RAF Centre of Aviation Medicine, Henlow, United Kingdom

(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: This case report describes the events of a twin seat RAF Hawk aircraft accident in which there was one successful ejection, but the second crew (passenger) failed to eject safely. This case also reviews the safe ejection envelope and demonstrates how the latest ejection seats, compared with the older Mk10B seats fitted in the Hawk, could increase the safe survivable ejection envelope. **BACKGROUND:** The Hawk is a training aircraft and flown typically with the experienced instructor in the rear seat and the student in the front seat. Hence, the command ejection system is set to ON: rear seat ejects front and rear seats, or front seat ejects independently. In this accident the experienced

pilot was in the front seat and the inexperienced passenger was in the rear seat, hence the command system was set to OFF: the occupants had to each eject independently. **CASE PRESENTATION:** The pilot was conducting a practice engine failure after take-off maneuver. On approach to the runway the pilot assessed that the aircraft had entered an irrecoverable attitude and initiated ejection at approximately: IAS 148 kts, 11.6 m (38 ft) AGL, 4.6° pitch nose up, 21° right AOB and a descent rate of 22.2m/s (73 ft/s). The pilot ejected but sustained major injuries. The rear seat occupant remained in the aircraft and did not survive the ground impact. **DISCUSSION:** As the command ejection system was set to OFF the investigation was aimed at firstly, determining if the rear seat occupant would have had sufficient time to initiate his own ejection before ground impact following the pilot's "eject-eject-eject" call, and secondly, if the ejection was initiated would the ejection have been within the safe ejection envelope. Ejection simulation modelling was conducted using the parameters identified from the ADR. The simulations predicted that if the rear seat had been initiated within 0.5 s of the front seat, the passenger would have just survived. The ejection would have been on the edge of the safe ejection envelope, and the passenger would have been at a high risk of sustaining major parachute landing injuries. Further simulations demonstrated that the survivability would be enhanced if the aircraft was configured with an ejection system where the front seat pilot could command initiate the rear ejection. Additional simulations also showed that the performance of the latest generation of ejection seats could have also increased the safe ejection envelope.

Learning Objectives

1. Understand how ejection system modelling can be used in the investigation of aircraft accidents.
2. Understand how improvements to ejection seat systems can improve aircraft accident survival

Wednesday, 05/20/2020
Regency 8

2:00 PM

[S-65]: SLIDE: HYPOXIA AND COGNITION

Chair: Desmond Connolly

Co-Chair: Dara Regn

[326] COMPARISON OF DEGRADED PHYSIOLOGIC STATE IN VOLUNTEERS EXPOSED TO +Gz AND HYPOXIA WITH THE HOLISTIC MODULAR AIRCREW PHYSIOLOGIC STATUS (HMAPS) SYSTEM

Barry Shender¹, Megan Gallo², Jessica Anderson³, Eric Joyce³, Phillip Whitley⁴, Jeremy Beer⁵

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³Athena GTX, Johnston, IA, USA; ⁴Criterion Analysis, Inc., Miami, FL, USA;

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(Original Research)

INTRODUCTION: To support US Navy's efforts to mitigate in-flight "physiological episodes" risk, TACAIR aircrew were monitored with HMAPS during human centrifuge (HC) and altitude chamber (AC) exposures. **METHODS:** HMAPS, a body-mounted, aircraft-independent system, measures pulse oximetry (SpO₂), pulse rate (PR), ECG, G_{xyz}, barometric pressure, and derives respiration rate. HMAPS cognitive impairment index (CI) estimates state based on SpO₂, task performance, and a cerebral perfusion model. A Summary State (SS) index fuses vital signs to estimate overall status. CI and SS have 5-point scales (5=max degradation). A G-fatigue (G-F) index uses PR and G-dose to estimate capacity with a 100% (no fatigue) to 0% scale. NAMRU-D conducted a study at KBR's Brooks City-Base, TX HC and AC with exposures on different days. Eight consented subjects breathed 95% O₂ while exposed to three simulated aerial combat maneuvers (SACM) with multiple 6G/s transitions (+7.5Gz max). A minimum 2min rest separated runs. Runs were halted when subjects' peripheral vision dropped to 60%. Subjects wore an anti-G suit and performed anti-G straining maneuvers. During AC hypoxia exposure,

5 subjects breathed air while exposed to 20 min at 2450m, then 30 min at 5350m at an ascent rate of 1,524 m/min. Subjects pulled a simulated "green ring" (GR) when they felt they would initiate in-flight emergency procedures, then received 100% O₂. This case study demonstrated HMAPS algorithm performance. **RESULTS:** One subject (SA) demonstrated higher hypoxia tolerance than the others, withstanding 1155s at 5350m compared to 333±155 for the rest. SA's SS and CI peaked at 4 (for 11.4% and 2.4% of the plateau, respectively) compared to SS≥4=43±4% and CI≥4=12±17% of the plateau for the others. Five subjects pulled the GR at SpO₂=71±6% at 5350m. To judge if SA's higher hypoxia tolerance extended to G-exposures, we highlight responses to the strenuous second SACM, which had four ≥+6.5Gz peaks. SA's G-F fell to 76% compared to 25±4% and took 135s compared to 158±14s to recover to 90% post exposure. SA's was SS≥4 for 87% and CI≥4 for 20% of the SACM as compared to SS≥4=82±12% and CI≥4=35±4% for the rest. **DISCUSSION:** While the small number of datasets limits generalization, note that SA who exhibited the greatest hypoxia tolerance and lower persistence of high SS and CI values also had the lowest G-F. This indicates the indices' potential to be sensitive to tolerance differences under both stressors.

Learning Objective

1. To understand how the HMAPS system detects increasing stress relevant to fast jet high +Gz and hypoxia exposures.

[327] QUANTIFYING COGNITIVE DEGRADATION DUE TO HYPOBARIC HYPOXIA

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(Original Research)

INTRODUCTION: Hypoxia-like symptoms are the most commonly reported attributes of airborne physiological episodes, although the exact cause of these episodes is far from certain. Hypoxia alone does not represent a danger to the aircrew; rather, cognitive degradation and eventual loss of consciousness resulting from the hypoxic state is the greatest threat. Here we tested a multi-model biomonitoring system in conjunction with machine-learning derived models to quantify cognitive degradation due to hypoxic hypoxia. **METHODS:** 12 USAF F-35 pilots were (11 males, 1 female) fitted with a helmet-mounted physiological monitoring system recording SpO₂, pulse rate, and atmospheric pressure. Subjects were seated in a hypobaric chamber and underwent a 30-minute 100% oxygen pre-breathe. Baseline cognitive state was assessed using a tablet-based test of executive function. Next, the hypobaric chamber was raised to 15,000 feet, then 25,000 feet pressure altitude. At each altitude, subjects removed their oxygen masks and completed the same cognitive test. After each test, subjects replaced their masks and were administered 100% oxygen. Finally, the hypobaric chamber was returned to ground level, and a final, post-exposure cognitive test was administered. Post-hoc data analysis calculated a Relative Performance Index (RPI). **RESULTS:** During the pre-breathe, mean oxygen saturation (SpO₂) was 99% (+/- 0.22%). At 15,000 feet, average SpO₂ declined to 96.2% (+/- 2.3%), and at 25,000 feet, mean SpO₂ further declined to 78.6% (+/- 3.4%). Post exposure, mean SpO₂ returned to 98.1% (+/- 1.6%). A decline in executive function was observed by a 600% increase in the number of errors made at 25,000 feet as compared to the baseline. Interestingly, cognitive function was not restored to baseline levels for the post-exposure test. RPI showed a decline in cognition at the 15- and 25-thousand foot levels. RPI at post-exposure period did not return to baseline levels, correlating well with the decline in cognitive function (p=0.002). **DISCUSSION:** As the aviation community attempts to maximize training effectiveness and human performance while mitigating risk, an objective tool to quantify cognitive status and draw attention to degraded cognitive performance is needed. A relative performance index as developed and presented herein could ultimately improve current risk mitigation techniques, as well as better detect and alert pilots to a degraded cognitive status.

Learning Objectives

1. The audience will learn about current physiological monitoring efforts/technologies.
2. The audience will learn about the implementation of machine learning/artificial intelligence in human performance modeling.
3. The audience will learn about quantification of cognition.

[328] UNDERSTANDING OXYGENATED BLOOD PULSE TRANSIT TIMES DURING HYPOXIA INDUCTION FOR DETECTION OF COGNITIVE IMPAIRMENT

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(Original Research)

INTRODUCTION: The human physiological response to stress/increased workload, as experienced aviators, involves sympathetic nervous system activation including vascular constriction. Our aim is to characterize and understand measures of vascular constriction (e.g., perfusion dynamics and heart rate) to predict cognitive impairment. Our analytic approach includes coupling of the photoplethysmogram (PPG) and electrocardiogram (ECG) signals to derive novel features of cardiovascular physiology. The physiological underpinning of this work is the timing delays of the systolic phase of the PPG signal and contraction phase of the left ventricle of heart indicated in the ECG. Analyzing the sensor data in this way enables calculating the Blood Pulse Transit Time (BPTT). BPTT is expected to decrease as vascular constriction increases. The implications of these timing delays are examined with traditional statistical analyses and entropic methods. **METHODS:** Professional pilots served as test subjects (n=57) in a study involving breathing air simulating sea level (21.0% O₂) and 15,000 feet (11.2% O₂) induced by an Environics, Inc. ROBD. Subjects experienced non-hypoxic and hypoxic exposures while performing three laboratory tasks. Physiological data (EEG, ECG, PPG, and SPO₂) were recorded and temporally synchronized. A QRS complex/peak detector was used to calculate the left ventricle contractions of the heart from the ECG. A detector for the end of the systolic phase of the blood pulse was used on the PPG signal. The time difference instances from each detector were used to derive BPTT. **RESULTS:** Preliminary results comparing the hypoxic and non-hypoxic epochs demonstrate significant changes in blood pulse transition time mean values and complexity metrics (p < 3x10⁻⁵, p < 0.0298 respectively; however differences in BPTT variance were not significant. Preliminary analyses indicate that as induction of hypoxia proceeds for 10 minutes and SPO₂ decreases, the BPTT decreases. **DISCUSSION:** The preliminary results indicate the impact of hypoxia induction on perfusion of blood and vascular physiological responses were characterized and predicted. These results inform the understanding of physiology stressors within aerospace domains in which perfusion of oxygenated blood is critical. A potential application of these predictive capabilities includes the development of real-time non-obtrusive systems controlling G-suits to regulate optimal oxygenated-blood perfusion.

Learning Objective

1. The audience will learn about how mild hypoxia exposure can impact operator performance.

[329] EXOGENOUS KETOSIS FOR IMPROVING HUMAN COGNITIVE PERFORMANCE DURING HYPOXIA

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(Original Research)

Studies have shown that during altitude-induced hypoxia, cognitive capacity degrades. In an operational setting, this can compromise performance. In an investigation into a potential solution for mitigating hypoxia effects on cognition, we observed that the impact hypoxia has on cognition differs by test type, suggesting that different cognitive processes are affected. Prior research has not identified these cognitive processes. Our findings begin to reveal these processes. The study that led to the findings was a randomized, crossover study that investigated the effects of a metabolic intervention on cognitive performance during normobaric hypoxia exposure. Eleven healthy male military aviation students were recruited. Participants completed several oculometric-based cognitive tests, in addition to several tablet-based cognitive tests under normoxic and hypoxic conditions following consumption of an experimental and a placebo drink. Relevant here is the effect that hypoxia had on cognition under the placebo condition. Results indicated a significant hypoxia effect for only one of the tablet-based cognitive assessments (code substitution) and one among the oculometric tests

(blink duration). Specifically, under the hypoxia condition participants performed significantly poorer on the code substitution task, and had shorter blink durations compared to when under the normoxic condition. The findings in this study provide an understanding of the types of cognition affected by hypoxia. Knowing this may help identify operational tasks negatively impacted at higher altitudes. Finding a significant cognitive effect for the more complex assessment and not the simpler assessments suggests that simple tasks requiring lower level cognitive processes such as quick reaction time (e.g., target detection) may not be affected by hypoxia. On the other hand, more complex tasks requiring higher order cognitive processes such as working memory (e.g., receiving and executing a close air support mission) could be affected to a greater degree.

Learning Objective

1. Gain a better understanding of the cognitive processes affected by hypoxia.

[330] INCREASED RESTING ALPHA EEG OSCILLATIONS DURING NORMOBARIC HYPOXIA

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(Original Research)

INTRODUCTION: Understanding the impact of hypoxia on brain activity is crucial for developing ways to mitigate hypoxic impairments. The first step in detecting these impairments is to understand the impact of hypoxia on spontaneous brain oscillations using electroencephalography (EEG). Compared to normoxia, we expect to find an altered alpha (8-12 Hz) and theta (4-8 Hz) power during five minutes of eyes open resting state hypoxia. **METHODS:** We tested 10 participants (3 female) who completed normoxia and a normobaric hypoxia (NH) (12.8% O₂, 87.2% N₂) testing on two separate days. Participants were instructed to visually fixate on a centrally presented white cross for five minutes while resting state data were recorded using a 64 channel EEG and an oxygen saturation monitor. EEG data were preprocessed to remove eye blinks and muscle artifacts, and bandpass filtered (1-50 Hz). We then performed source estimation using eLORETA, and calculated the change in power between the beginning and end of each condition. A within subjects non-parametric cluster based two tailed t-test ($\alpha=0.05$) was then performed. Significant clusters were projected to the cortical surface. We performed correlations on the first cluster with the average arterial oxygen saturation (SaO₂) of the last 50 s of the NH condition. These statistical tests were performed on relative power for each frequency band. This study was approved by the Simon Fraser University Research Ethics Board and conformed to the standards of the Declaration of Helsinki. **RESULTS:** With NH there was a significant increase in the relative power of alpha ($p=0.0032$), and a significant decrease in delta ($p=0.024$), and theta ($p=0.025$) compared to normoxia. Alpha power were concentrated in the frontal-central regions when projected to the cortical surface. We found that only the beta cluster was correlated with SaO₂ ($r=-0.75$, $p=0.0013$). **DISCUSSION:** To our knowledge, this is the first study to perform source-resolved EEG brain imaging during NH resting state EEG, and also the first study to correlate frequency band limited spontaneous EEG activity with changes in SaO₂. The increase in alpha we observed may reflect drowsiness brought on by hypoxia and may indicate an underlying inhibition in frontal brain areas suppressing cortical brain dynamics and connectivity which could be responsible for altering cognitive activity.

Learning Objective

1. The audience will learn about the impact of normobaric hypoxia on spontaneous brain oscillations recorded using an electroencephalogram.

[331] USING MACHINE LEARNING TO BUILD A HYPOXIA DETECTION MODEL

Dallas Snider¹, Steven Linnville², Jeff Phillips³, Sabrina Drollinger⁴, Jason Banuelos¹, G. Merrill Rice⁵

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(Original Research)

INTRODUCTION: The capability of recognizing symptoms of hypoxia and other cognitive impairments in-flight with wearable sensors and machine learning based algorithms would benefit the aviation community by saving lives and preventing mishaps. **METHODS:** In this study approved by the Naval Medical Research Unit Dayton IRB, 25 U.S. Navy designated aviators were exposed to increasing levels of normobaric hypoxia and monitored with a dry EEG system (DSI-7, Wearable Sensing, LLC, San Diego, CA) while flying a fixed-base flight simulation. Cognitive workload and changes in brainwave frequencies and amplitudes were quantified and analyzed with the included DSI DataStreamer software and MATLAB (The Mathworks, Natick, MA). Changes in flight and cognitive performance were analyzed via simulation tasks and a cognitive test battery validated under hypoxia (Hypoxia Edition, Cog-Screen, LLC, St. Petersburg, FL). Normobaric hypoxia was produced and SpO₂ was monitored using the Reduced Oxygen Breathing Device (ROBD₂, EnviroNics, Inc., Tolland, CT). The recorded SpO₂ levels were grouped into three classes: normal [95, 100], mild hypoxia [85, 95] and severe hypoxia [60, 85]. Features from the EEG data were extracted and used as input to machine learning algorithms to predict the SpO₂ level separately during the flight simulation and cognitive test battery tasks. For this initial phase of the research, the J48 decision tree, naïve Bayes, multilayer perceptron artificial neural network and k-nearest neighbor classification algorithms were used. **RESULTS:** For the flight simulation tasks, 22,353 data points were used as input to the classification algorithms. The sensitivity/specificity for the normal class was 0.75/0.75, respectively. For the mild hypoxia class sensitivity/specificity were 0.61/0.60, while for the severe hypoxia class, sensitivity/specificity were 0.65/0.65. For the cognitive test battery tasks, 15,211 data points were used as input to the classifiers. The sensitivity/specificity for the normal class was 0.80/0.80, respectively. For the mild hypoxia class sensitivity/specificity were 0.62 and 0.64, while for the severe hypoxia class, sensitivity/specificity were 0.69/0.68. **DISCUSSION:** The results reported above were attained by the k-nearest neighbor algorithm. These preliminary findings will be improved with better feature extraction and noise elimination with the goal of creating a real-time, onboard system to detect cognitive impairments.

Learning Objective

1. The audience will learn about research into using EEG signals and machine learning to detect hypoxia in real-time.

Wednesday, 05/20/2020

2:00 PM

Exhibit Hall

[S-66]: POSTER: SPACE MEDICINE

Chair: Patrick McGinnis

Co-Chair: David Reyes

[332] RADICAL SURVIVAL: MECHANISMS OF MICROBIAL RESISTANCE TO IONIZING RADIATION IN SPACE

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(Original Research)

INTRODUCTION: Microorganisms exposed to the conditions of spaceflight are impacted by high levels of ionizing radiation. This enables unique mechanisms of adaptation and alters their interaction with the environment and hosts. Here we review current data on microbial radiation resistance mechanisms in space and analyze potential implications for future missions. **METHODS:** The literature was reviewed to assess existing data on mechanisms of microbial resistance to radiation. Search terms in PubMed and Google Scholar included: biofilm, extremophiles, spores, radiation, resistance, microgravity, weightlessness, and spaceflight. Studies based in microgravity or analogous terrestrial settings were included. References were cross-checked for additional relevant publications. **RESULTS:** Radiation resistance has been studied in multiple organisms on both short and long-duration space missions

as well as in simulated microgravity. Many of the microorganisms studied are extremophiles that have been extracted from austere terrestrial settings. Existing literature analyzes bacteria, archaea, protozoa, cyanobacteria, fungi and lichens. Among the bacteria, *Deinococcus* species are the most radiation resistant and are able to tolerate both acute and chronic radiation exposure for up to several years. They utilize unique mechanisms of DNA repair and elimination of reactive oxygen species and biofilm formation. Of the lichens and fungi studied, *Xanthoria elegans* and *Buellia frigida* have demonstrated viability after long-term exposures to the vacuum of space. The spore form of *Bacillus* species has also demonstrated long-term viability, largely based on spore coat and matrix formation, DNA repair mechanisms, and low core water content. The cyanobacteria studied had lower survivability and were more susceptible to radiation damage.

DISCUSSION: Microorganisms in spaceflight have demonstrated resistance to high levels of ionizing radiation through mechanisms of biofilm and spore formation, DNA repair, and free radical reduction. While biofilms and resistant organisms are often considered hazardous to human health, spacecraft integrity, and interplanetary contamination, they may also have potential beneficial applications. Radiation resistance mutations may be utilized or transferred to other key organisms for the purposes of food and light production, terraforming, and radiation decontamination and shielding. These applications may be useful in both space and terrestrial settings.

Learning Objective

1. The participant will be able to identify unique mechanisms of microbial resistance to ionizing radiation in space.

[333] ANTIBIOTIC SELECTION FOR USE IN ACUTE INFECTION DURING SPACE FLIGHT: GEOGRAPHIC APPROACHES

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²The University of Texas Medical Branch, Galveston, TX, USA

(Education - Program / Process Review Proposal)

BACKGROUND: Data from the first 5 years of astronauts living on the ISS revealed that the skin of crew members is a primary source of contamination, with the predominant bacteria comprising the *Staphylococcus* genus. Antibiotic resistance has been a trait of bacterial species isolated from the ISS and various studies have demonstrated differences in bacterial virulence and antibiotic susceptibility when tested in modeled microgravity. This literature review aims to utilize data from local antibiograms to help guide antibiotic selection in spaceflight by examining the susceptibility trends of the environment where astronauts live and train. Antibiograms are a cumulative report that list the percentage of isolates susceptible to a variety of antibiotics, using data from patients receiving care at a specific place. They are evidenced-based tools to guide empiric therapy. **OVERVIEW:** This antibiogram (table 1) is a composite from two local medical centers, showing the four different antimicrobial options that have efficacy against gram-positive skin and soft tissue infections that are currently selected for Orion and one additional oral option. The antibiogram demonstrates high rates of susceptibility of MSSA/MRSA to TMX/SMP and low rates of susceptibility to clindamycin. Clindamycin is well known to have regional variability in its effectivity against *Staphylococcal* infections. Linezolid, not currently part of the Orion med kit, has higher efficacy in treating gram-positive infections and represents another potential option.

DISCUSSION: This data can suggest the susceptibility patterns specific to the region where astronauts live and train. However, major limitations exist on how well these local hospitals and their patient populations correlate to the astronaut population. Astronauts have substantial domestic and international travel prior to flights, which is likely to complicate the utility of local trends in deciding susceptibility. Bacterial organisms and drug mechanisms both act differently in spaceflight, further limiting the utility of terrestrial antibiograms in predicting organism susceptibility. Creating an antibiogram specific to the unique population of our astronauts will help make decisions on what antibiotics to use in spaceflight. Using software from the W.H.O., an antibiogram can be created by collecting the following information: culture date, culture source, culture results, antibiotic susceptibilities.

Learning Objectives

1. Understand how to utilize antibiograms to guide empiric antibiotic selection and to detect bacterial resistance patterns.
2. Utilize currently available evidenced-based medical practices to inform antibiotic selection for spaceflight.
3. Consider how an astronaut-specific antibiogram may help inform future aerospace medicine decisions.

[334] MANAGEMENT OF ANTICOAGULATION DURING HIGHER-BLEEDING RISK ACTIVITIES IN SPACEFLIGHT

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(Original Research)

INTRODUCTION: There may be indications for use of anti-coagulation in spaceflight. Anti-coagulation therapy reduces thromboembolic risk, but increases the risk for bleeding. Terrestrially, anti-coagulation is often interrupted during surgical procedures to reduce bleeding risk. Launch, re-entry, landing, and extra-vehicular activity place crewmembers at higher risk for injury and anticoagulation interruption may be beneficial in this setting, but there is a need to review and apply terrestrial evidence to the spaceflight environment. **METHODS:** PubMed was searched for guidelines regarding the management of anti-coagulation in the setting of surgery. Search terms included (anticoagulation OR antithrombotic) AND (perioperative care or periprocedural care). The search was limited to publications between 1/1/2010 and 10/1/2019. Results were filtered by guideline and review type. Title and abstract were reviewed to determine relevance. **RESULTS:** A total of 11 guidelines produced by 17 organizations or panels were identified. Seven guidelines included a strength of recommendation and a quality of evidence assessment. Eight guidelines included recommendations specifically mentioning direct acting anti-coagulants (DOACs). For very-high bleeding risk procedures, interruption was usually recommended. For lower bleeding risk procedures, the decision regarding interruption was usually conditional on the risk of thromboembolism. Newer guidelines incorporate evidence that bridging increases bleeding risk. DOACs require less time of interruption time than warfarin, and according to one guideline, may be interrupted even in the setting of high thromboembolic risk. **DISCUSSION:** Evidence-based guidelines recommend that the decision to interrupt anticoagulation be based on an assessment of both bleeding and thromboembolic risk. A similar approach to interruption of therapy could be applied to the spaceflight environment, incorporating patient-specific and activity-specific risks. A simple algorithm modeled after surgical guidelines could help determine whether and when to interrupt anticoagulation in spaceflight. Developing a standardized approach is especially important as commercial spaceflight may increase the number of people flying with complex medical problems.

Learning Objective

1. The participant will identify major guidelines for the management of anti-coagulation during surgical procedures and discuss their applicability to spaceflight.

[335] SPACE MOTION SICKNESS TREATMENT

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²NASA, Houston, TX, USA

(Original Research)

INTRODUCTION: Space motion sickness, a form of motion sickness experienced by astronauts in microgravity, is the most common clinical condition experienced during the first three days of spaceflight and can have a significant impact on well-being, performance, and mission planning. Despite awareness of space motion sickness (SMS) since 1961, the medical and scientific communities have not been able to fully understand the physiologic mechanisms at play that cause SMS or the best treatment for it. The use of terrestrial based methods to test efficacy of different pharmacologic SMS treatments have led to problems in translational success with inflight astronaut SMS treatment. To date, no clinical practice guideline has been established for treatment of space motion sickness for NASA flight surgeons and the

treatments used currently are derived from anecdotal reports or previous success. **METHODS:** A literature review was conducted to determine the best pharmacologic treatment for space motion sickness. The databases of PubMed and InfoHawk, the Journal of Aviation, Space, and Environmental Medicine, the Journal of Aerospace Medicine and Human Performance, and the NASA library were used. These following search terms were used: Space Motion Sickness, SMS, and Motion Sickness. The results were weighted, giving priority to in-flight microgravity studies then parabolic flights followed by other terrestrial based methods.

RESULTS: Results showed that the best published treatment for SMS in crewmembers has been promethazine 1M 25 mg, which is currently the most relied upon drug for SMS treatment in space. Prophylaxis has had variable success and should be up to the discretion of the crewmember and flight surgeon based on the crewmembers previous experiences with motion sickness and space motion sickness. Non-pharmacologic strategies were not superior to pharmacologic agents. **DISCUSSION:** The studies comparing pharmacologic outcomes for SMS drugs are few and far between secondary to crewmembers medical privacy and lack of applicable terrestrial analog data. SMS drugs should be tested on crewmembers prior to flight to test for adverse effects and reactions and possibly for efficacy given the wide individual variability to SMS drugs. Future research on this subject should incorporate data from the longitudinal study of astronaut health to acquire recent data on the specific SMS medications used in crewmembers and their effect.

Learning Objectives

1. Review the literature to gain knowledge about the incidence of space motion sickness, theories for its causes, symptoms, and countermeasures.
2. Identify gaps in knowledge in the literature and understand limitations and applicability of terrestrial studies.
3. Research the literature for the most effective countermeasure with a pharmacologic focus.

[336] ALERTNESS MEDICATIONS: A REVIEW OF POLICIES IN MILITARY AND CIVILIAN HIGH RELIABILITY ORGANIZATIONS

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(Original Research)

INTRODUCTION: Both training and spaceflight operations frequently require international travel, 12-hour or longer shifts, and multiple shifts in succession without adequate crew rest. Ground and inflight evidence shows that fatigue increases the risk for performance decrements¹. Given that the spaceflight environment is unique to NASA, human performance, fatigue, and the risk of catastrophic outcomes are not. This work strongly applies to High Reliability Organizations (HROs)². HROs are defined by extremely safe and reliable operations intended to reduce risk of catastrophic outcomes and include the commercial and military aviators, railroads, nuclear power plants, Special Operations Forces (SOF), and others. HROs have well-established standards for the use of alertness medications during operations. This study was to explore if NASA's draft policies are consistent with how other organizations facing similar risks associated with complex decision making under fatigue currently employ. **METHODS:** Policy statements, regulations, and firsthand accounts were collected from open source information and government databases. These policies were compared to NASA's draft policies regarding complex decision-making and alertness medication and assessed for similarities and differences. **RESULTS:** NASA's unpublished alertness medication policies are most like policies held by military organizations. Civilian aviators, rail workers, and commercial driver policies do not endorse alertness medication in workers but allow for use when prescribed. Nuclear power stations currently do not allow alertness medication.

DISCUSSION: Civilian and Military HROs utilize alertness medications divergently. Civilian HROs generally focus on work hour restriction and required rest periods as the ideal form of fatigue management. Pharmacologic methods are managed by the individual and their physician. The civilian sector typically does not require "slam shifts" or emergency utilization, which military members experience regularly during active operations. As such, military policies allow for focused and proactive use of alertness medications in aviators and SOF. NASA draft policies appear to

be in line with military aviators and SOF. Data collection for crew utilization, specifically to observe any changes in performance or adverse effects, is needed to increase mission effectiveness in the microgravity environment, especially given the prospect of long duration space missions.

Learning Objective

1. Understand NASA alertness medication policy in respect to other industries and further needed research.

[337] SELF-GENERATED LOWER BODY NEGATIVE PRESSURE DEVICE AS A SPACEFLIGHT COUNTERMEASURE

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¹University of California, San Diego, La Jolla, CA, USA

(Original Research)

INTRODUCTION: Detrimental physiologic changes associated with long-duration spaceflight, including cardiovascular deconditioning and spaceflight-associated neuro-ocular syndrome (SANS), may be related at least in part to head-ward fluid shifts. Lower-body negative pressure (LBNP) represents a potential countermeasure against these changes. However, it is not yet widely implemented. Practical challenges with its use, such as noise, mass, and power requirements have also not been fully addressed. The general function and refinement of a human-powered LBNP device—requiring no outside electrical input—is described here.

METHODS: An atmospheric pressure sensor (WPI PM015D) was used to determine the LBNP internal chamber pressure. A digital scale (Tree LSS 400) in the device monitored ground reaction forces (GRF) related to changes in the chamber pressure. Manual pressure release valves in the device allowed the rate of pressure normalization and thus exercise resistance to be modulated. **RESULTS:** At initial full extension, the average LBNP and GRF generated were -12.2 mmHg (SD=1.04) and 57.8 kg (SD=5.6), respectively (n=3). This GRF augmentation corresponds to 80.3–97.8% of the subjects' body weight. Changing the device's midsection length to closer correspond to the subjects' height increased the LBNP magnitude and GRF generated by the same subjects by an average of 40–68% and 30–54%, respectively, depending on exercise intensity and modulated by the rate of internal pressure normalization. When LBNP was generated at maximal extension, 50% of the initial LBNP level was lost after an average of 2 minutes and 7 seconds (n=2). **DISCUSSION:** The current device is capable of generating LBNP and GRF, but further device development is necessary to attain physiologic target levels (20–25 mmHg) of LBNP. Mechanical loading to a degree approaching the user's body weight is achieved through this exercise-generated LBNP. Further testing is necessary to explore the physiologic effects of this combined exercise-LBNP spaceflight countermeasure. Plans for future design improvements and adaptations for supine testing will also be discussed.

Learning Objectives

1. Participants will learn about the physiologic principles underlying lower body negative pressure countermeasures for spaceflight.
2. The audience will learn about recent developments in lower body negative pressure countermeasures for spaceflight.

[338] AN OPERATIONAL SCALE MODEL SHORT-ARM HUMAN CENTRIFUGE AS A CUBE SAT PAYLOAD

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(Education - Tutorial Proposal)

INTRODUCTION: Microgravity has been studied as one of the influential factors affecting astronaut health during space travel. With plans of long-term space flights, and the Moon and Mars as the next steps in human deep space exploration, missions could span from a few days to months. This imposes a wide variation to mission architecture and planning for commercial enterprises and national agencies as the spacecraft need to be equipped to protect astronauts against the effects of prolonged durations in microgravity. In the extreme these could lead to potentially life-threatening physiological responses inflight and during return to Earth or other large gravitational bodies. **TOPIC:** Our team at Simon Fraser University's Aerospace Physiology Laboratory is currently in the process of designing a compact short-arm human centrifuge

designed to be installed in a variety of spacecraft, using a minimal space allocation. To more thoroughly test the centrifuge prototype, we have proposed to implement a miniature version of this device as the payload of a CubeSat, a classification of Nano-satellites. **APPLICATION:** The CubeSat would use a single reaction wheel as an analog for the centrifuge. The reaction wheel would be used in combination with a series of magnetorquers to learn about how to cancel the torque effects of the centrifuge in a power efficient manner. Although the centrifuge will primarily produce torques in a single axis any variations in loading or vibrations in the motor will cause minor torques off axis. These will need to be actively monitored and cancelled in order to prevent unwanted rotation of the spacecraft. Using the information from the in-orbit testing, we will incorporate modifications to our subject-run studies on Earth using our ground-based centrifuge. This will enable us to more thoroughly develop and study countermeasures for space applications and will result in a more in-depth understanding of human physiological responses to artificial gravity in a microgravity environment.

Learning Objectives

1. The participants will be able to understand the importance of modeling human physiology innovation prior to prototyping and running human performance research.
2. Participants will learn about scaled, on-orbit testing of aerospace physiology equipment and its importance in mitigating risk in human performance research.

[339] UTILIZING THE INTELLIGENCE CYCLE TO DEVELOP FUTURE SPACEFLIGHT MEDICAL KITS

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(Original Research)

INTRODUCTION: Medical resource allocation for spaceflight missions has historically been entirely driven by subject-matter expert (SME) opinion. With the coming increase in the types and lengths of missions, there is a clear need for a more structured method to determine the contents of future kits. We propose using methods from the intelligence community to develop a process to create these medical kits. **METHODS:** The intelligence cycle methodology of tasking, collection, analysis, production, and dissemination were applied towards kit development. Known, presumed, unknown, unknowable (KPUU) framework was also used. Data from historical medical events (HME), SME opinion, and a Probabilistic Risk Assessment (PRA) were compared. **RESULTS:** Medical event categories ranked by SMEs did not match those listed in HME sources. Using similar categories, we arranged contents of the PRA model kit by what they would primarily be used to treat. While there were minor similarities, all three datasets revealed different categorical priorities for kit development. **DISCUSSION:** Certain medical events can be anticipated based on HME. SME opinion is important but may differ based on variations in training and experience. PRA models are useful in generating recommendations based on HME and SME input, but cannot be used alone. For this reason, we recommend the use of multiple inputs into PRA, with final decisions guided by SMEs. This work demonstrates that PRA models can augment the SME decision process, and intelligence methodology can be applied to the development of more robust spaceflight medical kits.

Learning Objective

1. Learn about a novel method for medical kit development utilizing techniques from the intelligence gathering community.

[340] AUTONOMOUS MEDICAL CARE DURING EXPLORATION CLASS MISSIONS: A REVIEW OF PREPAREDNESS FOR SURGICAL EMERGENCIES ON MARS

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(Original Research)

INTRODUCTION: Humans will hopefully explore Mars by the 2040s. One of the largest risks of exploration class missions is simply distance, as well as the extreme environment faced during spaceflight and on the

red planet. Planning and self-sufficiency are key to a successful Martian mission. Stabilization, transport, and robust telemedicine capabilities are not a feasible model for Martian emergencies. Contingency planning to allow surgery on Mars must be made, addressing the expected hazards secondary to the mission profile in addition to medical events anticipated in the crew. Recommendations for Crew Medical Officer training guidelines and necessary medical equipment are needed. **METHODS:** Systematic literature review and critical appraisal pertaining to surgery on Mars. Databases: PubMed, Google scholar, Web of Knowledge, NASA online archives, ESA online archives. Search terms: Surgery *AND Spaceflight, *AND Mars, *AND Submarine, *AND Antarctica; Robotic Surgery *AND Spaceflight, *AND Mars; Mars Analogue AND Surgery; Autonomous Robotic Surgery. **RESULTS:** Surgery in space has been considered previously. Surgery on mice was carried out during Shuttle missions, 3D printed surgical instruments have been tested in Mars analogue missions, robotic surgery in space is possible, and microgravity surgical workstations have been developed. Anticipated surgical emergencies include trauma, appendicitis, and urological conditions. **DISCUSSION:** Mars has 38% of the Earth's gravity, and most studies have been in austere medicine or microgravity. There is a significant mass, power, volume and training constraint for Mars missions – multipurpose robotics and 3D printing would mitigate this. Ultimately, prevention is better than surgery – healthy crew selection, countermeasures, and crew protection help alleviate a surgical emergency but do not prevent it entirely and so a plan is needed for the eventuality.

Learning Objectives

1. The delegate will be able to consider surgery on Mars as an eventuality, with the Mars environment defined and current published capabilities stated.
2. The delegate will gain knowledge of novel work in the literature to prepare for surgical emergencies on Mars including in analogues and extreme environments.
3. The delegate will understand that there is a significant mass, power, volume and training constraint for surgery on Mars.

[341] FOOT DROP REQUIRING SURGICAL INTERVENTION FOLLOWING LONG DURATION SPACEFLIGHT

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(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: This case report describes the diagnosis of lumbar disc herniation causing motor neuron dysfunction in an experienced astronaut following long-duration spaceflight. **BACKGROUND:** Back pain represents the most common acute complaint in astronauts on orbit. Additionally, astronauts are at an increased risk of spinal disc herniation as compared to the general population. The only imaging modality available on the International Space Station (ISS) is point-of-care ultrasound (POCUS). However, POCUS has not been used to diagnosis a significant cause of acute back pain in an active astronaut on orbit. **CASE PRESENTATION:** A 50-year-old female astronaut with more than 4,000 hours of spaceflight experience presented to clinic with complaints of progressively worsening right-sided sensory and muscular radiculopathy in the lower extremity that included foot drop. Her symptoms had started after an acute event with the advanced resistive exercise device (ARED) and managed her symptoms with a short course of corticosteroids following consultation with her flight surgeon. She returned to Earth via a nominal Soyuz re-entry and a post-flight MRI revealed a small, broad-based disc protrusion at L4-L5 with compression of the L5 nerve root on the right side. POCUS obtained at the same time in clinic revealed the same findings. The astronaut underwent decompressive laminectomy with resolution of her symptoms and a return to NASA flight status. **DISCUSSION:** POCUS is a valuable tool for diagnostic and procedural purposes. This case demonstrates the utility of this tool in arriving at clinical and image-based diagnoses that agree with each other. With further development and refinement of protocols and training, POCUS will become an indispensable medical resource for deep space exploration class missions. This case provides an example of an atypical POCUS target with diagnostic quality images that could guide therapy in a resource-limited environment such as a trip to Mars.

Learning Objectives

1. The audience will learn about a potential new use of point-of-care ultrasound (POCUS) to diagnose spinal pathology in austere environments.
2. The audience will learn about the epidemiology of spinal pathology in long-duration astronauts.
3. The audience will learn about the utility of POCUS in the hands of novice users.

[342] USING COMPUTER VISION TO MEASURE CREW BEHAVIORAL SKILLS DURING SIMULATED MEDICAL EVENTS IN SPACE

Benjamin Mormann¹, Roger D. Dias², Steven Yule²

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(Original Research)

INTRODUCTION: The success of long-duration exploration missions will depend on behavioral skills of astronaut crewmembers, including teamwork, leadership, communication, and situational awareness. In a prior study, we developed and validated the Spaceflight Resource Management (SFRM-MED) tool to measure behavioral skills of astronaut crewmembers. This tool can be used to track behavioral skills of astronauts-in-training. While tools such as this currently represent the gold standard for behavioral skill measurement, inter-rater reliability can be variable, and recruiting observers is costly. Thus, there is a need to develop reliable, cost-effective, objective tools to measure behavioral skills. In a prior study we demonstrated the feasibility of computer vision software to capture position/motion data. Here we investigate the feasibility of using this data to help predict behavioral skills measured by human raters.

METHODS: We captured six video clips of participants responding to medical events in our spacecraft simulator using a GoPro Hero 5 camera. OpenPose v1.3.0, an open-source, deep learning-enabled computer vision program, was used to track motion and position of participants. This data was used to calculate team proximity and total motion for each clip. Additionally, each of the six video clips were viewed by independent observers and team behavioral skills were rated on the SFRM-MED interactive online platform. **RESULTS:** Behavioral skill ratings showed substantial variability between teams. Team motion and proximity were plotted in a visual analytics dashboard, revealing significant dynamicity both during clips and between clips. Positional heat maps were created, providing a visual representation of participant interaction with the spacecraft simulator over time. **DISCUSSION:** In this study we demonstrated that it is possible to measure both behavioral skills and position/motion of astronaut-like participants responding to medical events in a spacecraft simulator. Both behavioral skill ratings and motion/position measurements demonstrated substantial variability. Our future work will investigate developing a machine-learning platform to predict behavioral skills from objective motion/position data.

Learning Objective

1. The audience will learn about the potential to use computer vision to measure behavioral skills.

[343] SOYUZ LANDING RISK FACTOR CHARACTERIZATION

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(Original Research)

INTRODUCTION: This study has tracked astronaut injuries during Soyuz landings. Currently it is unknown how landing conditions, spaceflight deconditioning, and crew anthropometrics affect injury types and risks. Understanding these relationships will allow better quantification of the risk of injury for future spacecraft designs. **METHODS:** An estimation of the occurrences of injury during Soyuz landings was determined using flight medical records from the NASA LSAH and supplemented with a retrospective and prospective survey questionnaire. Injuries were classified

into five discrete classes based on severity and long-term health risks. Mission variables were then analyzed against injuries through Spearman, logistic regression, and injury percentage comparison. Mission variables include age, gender, mission duration, extravehicular activity (EVA) time, vehicle type, location in vehicle, weather condition, landing orientation, ground conditions, wind speed, temperature, air pressure, and humidity. **RESULTS:** Injuries predominate in the shoulders, arms, back, and knees and tend to be of lower severity, but greater than previously predicted. Seat location increased injury chance by 22%, with a predominance of injuries occurring in the right seat. Female astronauts experience injuries 24% more than males and have a 54% chance of being injured overall. Logistic regression and Spearman analysis show no statistically significant results with available variables. When measured co-dependently, ground conditions with wind speeds most correlate with injury rates. **DISCUSSION:** Predominance of right side seat injuries may be explained by orientation of the vehicle at landing, and vehicle travel direction. Female astronauts exhibit differences in strength and musculoskeletal composition from males, which may be exacerbated by the deconditioning effects of space, leading to an overall lower tolerance to impact loading. Increased ground stiffness and wind speed contribute to the kinetic energy of the vehicle at landing, which most correlate with injury. Limitations of this analysis include astronaut surveys are collected retrospectively, Soyuz seat acceleration data are not available, and landing conditions are general estimates of the landing zone. Given the low number of Soyuz landers and even lower number of injured crew, more astronaut landing data are needed to strengthen statistical correlations in order to better quantify the risk of injury for future spacecraft designs.

Learning Objectives

1. How landing conditions, spaceflight deconditioning, and crew anthropometrics affect injury types and risks associated with Soyuz landings.
2. Understand the importance of astronaut risk assessment in current and future spacecraft landings.

[344] A CASE OF SILENT SINUS SYNDROME IN AN EUROFIGHTER PILOT

Frank M. Jakobs¹, Susanne Bartelmann², Diana Hering¹,

Anja Gross¹, Sven-Erik Sönksen¹, Frank Weber¹

¹German Air Force Centre of Aerospace Medicine, Fuerstenfeldbruck, Germany; ²74th Tactical Air Force Wing, Neuburg, Germany

(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: Silent Sinus Syndrome (SSS) is a rare disease presenting with unilateral enophthalmos, facial asymmetry, and diplopia due to orbital floor collapse caused by negative pressure from preexisting maxillary sinus atelectasis. **BACKGROUND:** So far, about 150 cases have been reported in the world literature. This case, to our knowledge, is the first report of a SSS in a military fighter pilot. **CASE PRESENTATION:** A 34 yo Eurofighter pilot presented with a self-reported, painless enophthalmos of his right eye. Apart from a low-grade facial asymmetry, no further symptoms or functional deficiencies were complained. Subspecialty examinations revealed a mucocele of his right maxillary sinus which was surgically removed, and a superimposed erosion of the orbital floor which was not surgically addressed in order to not further interfere with the topography of the eye. Yet, following surgery, a slight esotropia persisted in extreme supero-lateral eye position, indicating tractive inhibition of an extraocular muscle and causing inconstant microstrabism. Operational performance testing w/helmet on revealed no diplopia within the relevant binocular visual field. After six months free of complaints, a waiver was granted and the pilot readmitted to flight duties. **DISCUSSION:** It is well known that SSS may cause diplopia due to affection of the orbital bone and successive dislocation of the globe and/or incarceration of one or more ocular muscle(s). In a military pilot, this may impose a relevant flight safety problem up to in-flight incapacitation when primarily vertical diplopia is present and affects the visual field in forward or oblique direction. In the case reported here, the underlying motor deficiency was inconstant, minimal in extent, and present in extreme position only which has to be considered a lucky happenstance for the referring pilot. **CONCLUSION:** Our case documents the importance of taking individual self-observations of pilots seriously, as well as the impact of a collaborative check-up including MRI and consideration of other reasons of acquired enophthalmos. We conclude that clinical apparent

silent sinus syndrome does not necessarily require permanent grounding of a military fighter pilot.

Learning Objectives

1. The participant will learn about epidemiology, diagnosis and treatment options of silent sinus syndrome.
2. The reader will understand the pathophysiology of silent sinus syndrome.
3. The readership will realize the importance of taking individual self-observations of pilots seriously, as well as the impact of a collaborative check-up including magnetic resonance imaging and consideration of other reasons of acquired enophthalmos.

[345] "FRIEND OR FOE"? IS MY APPENDIX USEFUL, AND SHOULD I TAKE IT WITH ME IF I'M GOING TO MARS?

Rowena Christiansen¹, Anthony Shafton¹

¹University of Melbourne, Melbourne, Australia

(Original Research)

INTRODUCTION: Traditional belief holds that the human appendix is a vestigial organ devoid of any purpose, and consequently, surgical appendectomy has been the "gold standard" treatment for suspected appendicitis. Prophylactic (preventative) appendectomy remains the policy of the Australian Antarctic Division for wintering medical practitioners and has been discussed in the context of long-duration non-orbital space flight. **AIM:** New research around appendiceal function, increasing adoption of non-surgical treatment modalities for acute appendicitis, and emerging research on the long-term consequences of appendectomy have recently enabled researchers to challenge this paradigm. **METHODS:** This novel project set out to test the hypothesis that a "one size fits all" prophylactic appendectomy policy may not be in the best interest of individual expeditioners, and utilized a "mindmap" to identify several key areas for a scoping literature review. This enabled disparate research to be drawn together in an innovative way. **RESULTS:** A growing body of research has discovered that the appendix plays an important role in the gut immune system and maintaining gut health. It acts as a reservoir of good bacteria that repopulates the gut after pathogenic challenge. This is particularly important for people with impaired immune systems, such as those that occur in extreme environments. Appendicitis can often be successfully treated with intravenous antibiotics. Prophylactic appendectomy is not without risk, as 1:4 to 1:3 people will encounter some sort of postoperative complication. After an appendectomy, there is an increased risk of many serious medical conditions, including intra-abdominal adhesions, ischemic heart disease, inflammatory and irritable bowel diseases, rheumatoid arthritis, and many others. **DISCUSSION:** The increased morbidity and mortality associated with appendectomy is costly for individuals (the burden of disease) and society (health economics). It also poses a currently unappreciated health risk for long-term off-world expeditions.

Learning Objectives

1. Readers will learn about the extensive body of research demonstrating that the human appendix has a purpose.
2. Readers will gain an appreciation of alternatives to appendectomy for treatment of suspected acute appendicitis.
3. Readers will gain insight into the wide range of chronic diseases which are statistically more likely to develop post-appendectomy.

[346] AN INVESTIGATION INTO THE FEASIBILITY AND DESIGN OF A MICROGRAVITY SURGICAL WORKSTATION

Eleonor Frost¹

¹University College London, London, United Kingdom

(Original Research)

INTRODUCTION: As humanity plans for long-duration crewed missions to Mars and beyond, astronauts will need more autonomy and training to deal with medical emergencies. Significant communication delays and long evacuation distances mean a surgical workstation will be a necessity on a spacecraft and could save lives. **METHODS:** The aim of this study was to assess the feasibility and design of such a microgravity surgical workstation. This research was conducted using two main approaches: the first was a thorough literature review to summarize current knowledge and inform the enclosure design; this was followed

by an iterative process to perfect a workstation design proposal. Notably, a similar surgical enclosure has never been investigated and very few containment solutions have been tested in parabolic flight. **RESULTS:** This study proposes the design of a Crew Operating Microgravity Theatre Enclosure (COMTE), which has been shaped by conclusions from parabolic animal surgery experiments and by questionnaire feedback from space medicine experts and astronauts. A full technical characterization of the proposed design is included in this report, and a prototype was constructed. The defining principle of the COMTE 'glovebox' was to use the capillary edge-effect of fluids in microgravity to contain surgical fluids and blood during an operation. This aims to improve operator visualization of the surgical field, whilst maintaining a sterile surgical site and preventing contamination of the closed-loop spacecraft atmosphere. Additionally, the proposed design includes extensive research on weight, volume and power requirements, and has been reviewed by external experts. This research not only safeguards astronauts but could present a unique solution to terrestrial surgery in remote and extreme environments.

DISCUSSION: In conclusion, this presentation proposes a novel solution to the problem of safe and efficient surgery in space, and further work on the design will lead to testing on the ground and in parabolic flights.

Learning Objectives

1. To understand the current provision for surgery in a space environment.
2. To present a novel solution to the safe performance of surgery in space.

[347] A NEW ERA OF SPACE MEDICINE EDUCATION IN AUSTRALIA

Gordon Cable¹, Robert Thirsk², Angie Bukley³, Gilles Clément³

¹Australasian Society of Aerospace Medicine, Adelaide, Australia;

²International Space University, Strasburg, France; ³Lyon Neuroscience Research Center, Bron, France

WITHDRAWN

Wednesday, 05/20/2020
Centennial Ballroom II/III/IV

4:00 PM

[S-67]: PANEL: THE RAM BOWL

Sponsored by American Society of Aerospace Medicine
Specialists

Chair: Al Parmet

Co-Chairs: Rebecca Blue, Jan Stepanek, Robert Johnson

[348] THE 12TH ANNUAL RAM BOWL

Allen Parmet¹, Rebecca Blue², Jan Stepanek², Robert Johnson³, Roy Allen Hoffman⁴, Mary Cimrmancic⁵, Walter III Dalitsch⁶, Rahul Suresh³

¹University of Southern California, Kansas City, MO, USA;

²Mayo Clinic, Scottsdale, AZ, USA; ³University of Texas Medical

Branch, Galveston, TX, USA; ⁴U.S. Navy Bureau of Medicine

and Surgery, Falls Church, VA, USA; ⁵Marquette University,

Milwaukee, WI, USA; ⁶U.S. Naval Hospital, Sigonella, Sicily, Italy

(Education - Tutorial Proposal)

The 12th Annual RAM Bowl features teams from the Air Force, Navy/Army, Mayo Clinic, University of Texas and an International team 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. Teams complete in a college bowl format that tests aerospace medicine competencies, recall speed, teamwork and individual knowledge. Topics include the specialty 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 regulations, passenger transport, restraint and escape, cockpit resource management and AeroMedical transportation. Questions are divided into toss-up questions and bonus questions. Multiple rounds of competition will lead to the selection of this year's victor and awarding of the Louis H. Bauer Trophy, 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.
3. Conference attendees will gain insight into life, the universe and everything.

THURSDAY, MAY 21, 2020

Thursday, 05/21/2020

8:15 AM

55TH ANNUAL HARRY G. ARMSTRONG LECTURE/PANEL

Thomas Dimitroff

"SELECTION AND TRAINING IN PROFESSIONAL SPORTS"

Thursday, 05/21/2020

9:30 AM

Exhibit Hall

[S-68]: POSTER: PHYSIOLOGY

Chair: Peter Hodkinson

Co-Chair: Nathan Almond

[349] NEAR-INFRARED SPECTROSCOPY DURING HYPOBARIC HYPOXIA TRAINING IN A HIGH ALTITUDE CHAMBER

Andreas Werner¹

¹GAF - Centre of Aerospace Medicine, Königsbrück - Saxony, Germany

(Original Research)

INTRODUCTION: Flying staff is endangered by altitude-induced oxygen (O₂) reduction. Hypoxia is an O₂ lack at the cellular level which leads to disturbances of the functional and structural metabolism, and finally necrosis. Peripheral O₂-saturation (SpO₂) monitoring is standard during the hypobaric hypoxia training (hht) in our high altitude chamber. Physiologically, hypoxia induces a centralization; therefore, we postulated that this monitoring could be insufficient. Near-infrared spectroscopy (NIRS) is an entirely new technique measuring central oxygenation (rSO₂) relatively. Aim of the study was the comparison of peripheral to central oxygenation. **METHODS:** 108 voluntary training participants (written informed consent, 99 ♂; 34.9 ± 7.5 ys; 180.5 ± 6.9 cm; 81.2 ± 9.6 kg; 34.9 ± 2.1 kg/m²; 99 righthander, 21 smokers) were included in the study. The profile of the hht was: plateau at 25kft (acute) and mild hypoxia at 15kft. The standard monitoring was 1-ch-ECG, Hf, and SpO₂ (Masimo[®], M55). The regional O₂ measurement (frontal brain tissue) was obtained bihemispheric with NIRS (INVOS[™], 5100C). The trainees were asked to report their hypoxia symptoms. After data synchronization, the characteristics were analyzed. **RESULTS:** The values for SpO₂ and rSO₂ were significantly different (p < .001) and not correlated (CCC .002). Percental desaturation of rSO₂ and SpO₂ were significantly different (p < .001) and weakly correlated (CCC .488). The bias of both methods is high and the limits of agreement with >10% unacceptable. There were found no differences in left and right NIRS (pns, CCC .838). The duration for reoxygenation for rSO₂ and SpO₂ were significantly different (p < .001; rSO₂ recovers delayed (25s vs 58s [25kft], 40s vs 92s [15kft]). rSO₂ is less interference-prone than SpO₂ (95 vs 0 events). **DISCUSSION:** The NIRS oximetry is a valid method measuring central oxygen saturation. A bihemispheric measurement seems to be unnecessary. It detects the regional hypoxia reliably, and hypoxia symptoms correlate significantly better with the rSO₂ curves. NIRS is a valuable supplement to monitor blood saturation. Pulse oximetry during hypoxia demonstration was delayed and did not reflect the symptoms correctly concerning the time axis. The delay in reoxygenation found in rSO₂ could maybe explain the somnolent behavior. Further investigations will show if NIRS could be used as the new monitoring. Conceivable, this could be to monitor trafficking aircrews and increase safety.

Learning Objectives

1. The near-infrared spectroscopy (NIRS) is a appropriate method to monitor oxygen saturation in the blood during hypobaric hypoxia training.
2. The NIRS could detect earlier the deoxygenation and therefore increase safety in the training.

[350] RELATIONSHIP BETWEEN BEHAVIORAL CHANGE AND HIGH GRAVITY EXPOSURE BY AN ANIMAL MODEL

Min-Yu Tu¹, Gary Ro-Lin Chang², Chuan-Mu Chen², Chung-Yu Lai¹, Chia-Sheng Chen¹

¹Kaohsiung Armed Forces General Hospital Gangshan Branch, Kaohsiung City, Taiwan; ²National Chung Hsing University, Taichung City, Taiwan

(Original Research)

INTRODUCTION: High gravity (G) training is a strenuous exercise and stress for fighter pilots. Previous studies found that high G training can lead to several physiological and psychological effects, such as acute fatigue, residual motion sickness, and depression. However, there are difficulties to quantify those effects of behavioral changes on human pilots. **OBJECTIVES:** The aim of this study was designed to establish a reliable Sprague Dawley (SD) rat model that reflects the behavioral changes after high G exposure. **METHODS:** Eight adult male SD rats were used in this experiment. All rats were housed in the environment of 12/12-hour light and dark cycle with a temperature of 23±1°C and a humidity of 50±10%. Rats were free to access food and water. On the day before the experiment, the rats were firstly applied to high plus maze and open field tests. High G environment was performed by 8G/30 seconds for two rounds by using a human centrifuge. After centrifugation, rats