

warfighter performance, safety, medical care, and mission success in polar environments.

Learning Objectives

1. Audience will learn how seven nations are preparing warfighters for military operations in polar environments.
2. Audience will learn what are current limitations in human performance and medical care in extreme cold and/or austere environments.

[116] IMPACT OF EXTREME COLD ON COMBAT CASUALTY CARE

Bill D'angelo

Naval Medical Research Unit, San Antonio, TX, United States

WITHDRAWN

[117] EQUIPMENT AND INSTRUMENTATION TESTING FOR POLAR ENVIRONMENTS

Jorge Chavez Benavides

Air Force Research Laboratory, Dayton, OH, United States

WITHDRAWN

[119] THE LINK BETWEEN FOOD, GUT, AND WARFIGHTER PERFORMANCE

Lynn Cialdella-Kam

Naval Health Research Center, San Diego, CA, United States

(Education - Tutorial/Review)

Meals, Ready to Eat have been optimized to provide energy and nutrient needs to support warfighter performance during cold weather operations (CWOs). Warfighters, however, are often in caloric and nutrient deficit during CWOs due to such factors as time or situational limits, lack of appetite, and fatigue. Thus, nutrition interventions targeted to optimize the health and well-being of warfighters prior to CWOs may be ideal. The goals of this presentation are to (1) provide a brief overview of energy and nutrient deficit research, (2) summarize the link between food and gut health, and (3) explore the implications for warfighter performance. Specifically, foods high in polyphenols (i.e., natural food components that confer health benefits) and other nutrients (e.g., vitamin D, magnesium, and calcium) will be linked to musculoskeletal and immune health. In addition, evidence of the link between nutrients and mood will be described. Lastly, the presentation will conclude with potential nutrition strategies to prepare warfighters prior to CWOs.

Learning Objectives

1. Understand the energy and nutrient deficit during cold weather operations.
2. Identify the link between polyphenols, gut health, and inflammation and oxidative stress.
3. Understand the implications of nutrition aspects for warfighter performance during cold weather operations.

[120] ICE-PPR HUMAN PERFORMANCE – ARCTIC AND COLD WEATHER CLOTHING OVERVIEW

Chris Diaz

Navy Clothing and Textile Research Facility, Natick, MA, United States

(Education - Program/Process Review)

BACKGROUND: As the Polar environments change, commercial, scientific, and national security operations in the Arctic will continue to increase. Proper clothing selection is a critical factor in human performance and survivability, especially when operating in extreme environments. This presentation will provide an overview of US military

efforts to address cold weather clothing capability gaps. **OVERVIEW:** The International Cooperative Engagement – Program for Polar Research (ICE-PPR) Human Performance – Clothing sub-working group members are collaborating to improve cold weather protective clothing capabilities for safe operations in polar environments. This presentation will focus primarily on US military services' cold weather clothing research, development, testing and evaluation efforts, including the use of instrumented thermal manikins to assess the thermoregulatory performance of clothing ensembles. Existing operational decision aids have gaps in thermal protection performance of clothing when fully and partially wet in cold water and cold air environments. Further, there are opportunities to improve operational decision aids to better predict performance of protective clothing for women. Additionally, there are research and evaluation efforts exploring plant and animal bio-based alternatives to synthetic polymeric fibers to address future material availability gaps resulting from supply chain limitations and microplastic pollution reduction. **DISCUSSION:** Operational decision aids utilizing predictive models for survivability are tools for military commanding and aeromedical officers to use to make data-informed protective clothing selection decision for those in their charge to reduce cold and heat stress injury risk. The clothing protection data library and decision aid tools have applications beyond the military, including for search and rescue operations.

Learning Objectives

1. The audience will understand military considerations for cold weather protective clothing.
2. The audience will understand the usage of laboratory-based clothing ensemble assessments for military operational decision aid tools.

TUESDAY, MAY 07, 2024

Tuesday, 05/07/2024

10:30 AM

Grand Ballroom CD South, EF

[S-24]: PANEL: IDENTIFYING NEEDS AND RECOMMENDATIONS FOR MEDICAL SCREENING PERSONNEL PROVIDING PREFLIGHT EVALUATION OF COMMERCIAL SPACEFLIGHT PARTICIPANTS

Chair: Andrea Hanson

Co-Chair: Alejandro Garbino

PANEL OVERVIEW: This panel will explore the growing demands on Aerospace Medical Examination needs, current policy, and shaping strategic growth to support the emergent commercial spaceflight participant community. The panel will explore the current metrics related to AME Certified Professionals and demand for examinations, look at the anticipated growth in commercial spaceflight participants in the next 5-20 years, and encourage commentary and discussion regarding future policy and regulation required to ensure the safety of commercial spaceflight participants. The driver for this discussion is twofold: 1) The rise in commercial human spaceflight opportunities for civilians, and 2) impending expiration of FAA moratorium on medical screening standards/requirements for spaceflight flight participants. The panel will include international government and civil aerospace medicine perspectives, as well as insight from related extreme environment communities such as the global diving and wilderness medicine communities. A primary focus will be to collect a summation of best practices in medical examination and care from established communities and share lessons learned to support the growing commercial spaceflight sector. The panel will seek to identify the current major players in civilian spaceflight and potential benefits of more formally shaping standards and regulations to support both AMEs and spaceflight participants. The panel will share comments and positions collected by

the Space Medicine Association and aim to form a consensus representative of related communities in an effort to provide guidance to regulatory agencies from this highly specialized field of experts.

[121] WHO SCREENS THE SCREENERS? PERSONNEL CONSIDERATIONS FOR PREFLIGHT MEDICAL EVALUATION OF COMMERCIAL SPACEFLIGHT PARTICIPANTS

Jennifer Law

UTMB, Galveston, TX, United States

(Education - Program/Process Review)

BACKGROUND: The number of commercial spaceflight participants (SFPs) has increased dramatically in recent years and will continue to rise. To date, under a Congressional moratorium barring the Federal Aviation Administration (FAA) from regulating the nascent commercial spaceflight industry, companies have approached preflight medical evaluation in diverse ways. Once this "learning period" expires, the FAA may establish regulations or continue to allow industry to develop consensus standards. This presentation will provide a commercial flight surgeon's perspective on personnel considerations for preflight medical evaluation of commercial SFPs. **OVERVIEW:** Commercial human spaceflight presents a shift from the traditional, government-funded paradigm in astronaut selection, medical certification, and operational support. In the setting of business-driven decisions, companies tend to employ few medical personnel, who must design and then implement new processes, typically with limited guidance and support. Additional challenges include geographically diverse clientele, pressure to "medically clear" as many customers as possible, and medicolegal liability. A distinction between medical screening and clearance will be made. Illustrative examples will lead to recommendations for the qualifications of medical personnel for commercial spaceflight, which include an understanding of the aerospace environment and operational space medicine experience. Both physical and psychological issues should be considered in preflight medical evaluations. **DISCUSSION:** Whether by government regulation or industry consensus, preflight evaluation of commercial spaceflight participants should ideally meet minimum medical standards out of best practice, transparency, and fairness. Concurrently, standardization of personnel qualifications would ensure aerospace medical practices incorporate knowledge built on over 60 years of supporting human spaceflight while helping to reduce medicolegal liability, not only for the physicians but also for the whole industry. This discussion should be of interest to companies, current and future flight surgeons in commercial spaceflight, and regulators.

Learning Objectives

1. [The audience will learn about...] the challenges associated with preflight medical evaluation of commercial spaceflight participants.
2. [The audience will learn about...] the recommended qualifications of medical personnel for preflight medical evaluation of commercial spaceflight participants.

[122] WHAT KEEPS US UP AT NIGHT? BLACK SWANS IN SPACE

Jay Lemery, Alex Garbino, Andrea Hanson

NASA, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: The rise in commercial human spaceflight opportunities for civilians and varying medical screening standards for commercial spaceflight flight participants will result in increased risk of medical event 'outliers' in spaceflight. We illustrate an analogue case from polar medicine to discuss unpredictability in risk models, as well as the need for novel medical systems to better embed flexibility and resilience for long duration missions. **OVERVIEW:** At 5:30 A.M. on June 14th 2018, a polar bear walked into Summit Station—the NSF's research station in remote Greenland—nearly 300 m from individuals sleeping in arctic

tents. Summit Station possessed no bear deterrents other than heavy machinery. Over 40 Station residents were required to shelter in the two hard-sided buildings for 36 hours. Having little recourse to relocated the animal, ultimately hunters were flown to Summit Station and euthanized the bear. The epilogue of this encounter was a cascade of mental health complaints amongst the camp denizens, with reactions that included fear, anger, indifference, anxiety, grief and guilt stemming from the loss of autonomy, experiencing or witnessing a life-threatening encounter and the bear's death. The US-based medical team in support of Summit Station quickly mobilized psychiatric first aid support for the camp, in an effort to normalize reactions, explain coping mechanisms and re-establish a group connection (1). **DISCUSSION:** When considering medical risk assessment for extreme and/or remote missions, this encounter epitomizes a 'black swan' event—beyond any historic predictive data and characterized by unpredictability; has a potentially massive impact to the mission; and post-hoc predictability, with a sentiment that this encounter was less random and more predictable than it actually was, often saying it was "bound to happen." (2) As NASA endeavors to create evidence-based risk databases and predictive analytics for long duration missions, the 'black swan effect' reminds us that unforeseen outliers demonstrate the fragility of systems based on prediction and standard deviation; the dangers of placing too much confidence in a narrowly-focused expertise; and how rare and unpredictable events have a much greater impact than regular occurrences. This Arctic event speaks to the importance of resilient progressively earth independent medical systems that include redundant characteristics and improvisational skillsets.

Learning Objectives

1. The participants will understand the the fragility of systems based on prediction and standard deviation.
2. Participants will comprehend the dangers of placing too much confidence in a narrowly-focused expertise.
3. Participants will discern in large systems how rare and unpredictable events have a much greater impact than regular occurrences.

[123] EXPLORING THE NEED FOR AN EVIDENCE-BASED AND COLLABORATIVE APPROACH TO DEVELOPING REGULATORY MEDICAL STANDARDS FOR SUBORBITAL SPACEFLIGHT PARTICIPANTS

Ryan Anderton

UK Civil Aviation Authority, London, United Kingdom

(Education - Program/Process Review)

BACKGROUND: The UK Civil Aviation Authority (CAA) became the regulator for UK space activities in 2021, with the responsibility of developing medical standards for spaceflight participants and providing guidance relating to the standards/training requirements for AMEs undertaking participant/crew medicals. This presentation will discuss the importance of an evidence-based approach in developing standards for a very different risk profile compared to other aviation activities.

OVERVIEW: The regulations that currently govern human spaceflight participation are broad and have been intended to prevent restricting the development of emerging operators during this 'learning period', an approach adopted by the FAA. Section 17 of the UK Space Industry Act and The UK Space Industry Regulations 2021 set out the requirements for launch operators, including the requirement for informed consent of their crew and participants to undertake spaceflight activities. There is currently limited medical experience and knowledge on individuals with significant medical history who have flown in space. Most of the physiological and medical data collected to date is from generally healthy individuals, such as career astronauts who are selected in part based on physical fitness and the absence of disease. With the advent of commercial spaceflight operators, space is becoming increasingly accessible to the public, many of whom would have been excluded from astronaut selection based on medical history alone. Whilst considerable data exist regarding the effects of gravitational (G) forces on human physiology, the effects on suborbital spaceflight participants, particularly in those with

pathology, is minimal. Although short in duration, such flights involve considerable G-forces that may either impair the experience or pose a direct risk to health. **DISCUSSION:** Research currently being funded by the UK CAA includes centrifuge-based acceleration studies as well as computational fluid dynamic modelling to predict the effects of sub-orbital spaceflight on several medical conditions aiming to address the need for evidence-based policy. As we move closer to potential operators launching from UK soil, the UK CAA is looking to collaborate with the international aerospace medicine community in the development and evolution of medical standards and AME training guidance to provide greater assurance to the public.

Learning Objectives

1. The audience will learn about the current, and potential future regulatory requirements for operators, designed to safeguard human spaceflight participants.
2. The audience will gain an understanding of how research can contribute to the development of evidence-based spaceflight participant medical standards.

[124] NAVIGATING LEGAL AND ADMINISTRATIVE CHALLENGES IN HIGH-ALTITUDE AND NEAR-SPACE PROJECTS

Giugi Carminati

C2Space Tech LLC, Aurora, CO, United States

(Education - Program/Process Review)

BACKGROUND: High-altitude and near-space projects have emerged as cutting-edge endeavors that push boundaries while providing a test bed for technologies, methods, and approaches. However, these ventures also introduce novel legal & administrative challenges that demand careful consideration and planning. **OVERVIEW:** This presentation explores the multifaceted aspects of administering personnel, obtaining insurance coverage, and addressing liability waivers for high-altitude and near-space projects. By carefully addressing project management, insurance, and waivers, legal & ops personnel can enhance mission efficiencies while minimizing legal risks. This presentation serves to arm physicians and operators with an organizational framework.

DISCUSSION: Administration is a critical aspect of these projects, involving the coordination of entities and individuals across disciplines, states, and operational roles. Understanding the distinction between medical consulting and medical support, for instance, is essential, as is ensuring compliance with state laws, licensing obligations, and appropriate insurance coverage. In addition, effective project management and payroll classification are unseen yet necessary components of proper execution. In addition, because of the nature of the work (sporadic with uncertain timelines and dynamic shifts in personnel needs), having team redundancy is both challenging and paramount. Insurance is another dimension, with projects needing to assess whether they require various types of insurance, as as General Commercial Liability, medical malpractice insurance, Errors and Omissions, Umbrella policies, and/or vehicle liability insurance. This evaluation safeguards the project and mitigates risk. Finally, the legal landscape for high-altitude and near-space activities is complex, in part due to the United States federalist structure and the absence of federal tort laws. This situation leaves uncertainty and inconsistencies at the state level. Navigating this legal terrain is paramount to project success and compliance. This presentation introduces the specific challenges of liability waivers for high-altitude and near-space projects. These challenges include the selection of state laws and ensuring adequate protections under those laws. In conclusion, high-altitude and near-space projects present a dynamic environment that requires a comprehensive understanding of the legal, administrative, and operational intricacies.

Learning Objectives

1. Understand the operational complexities of high-altitude and near-space projects, including the coordination of personnel, compliance

with state laws, and the distinction between medical consulting and medical support.

2. Identify the various insurance considerations for high-altitude and near-space projects, such as General Commercial Liability, medical malpractice insurance, Errors and Omissions, Umbrella policies, and vehicle liability insurance, and assess their importance in mitigating project risks.
3. Gain insights into the legal challenges and complexities involved in high-altitude and near-space projects, including the selection of state laws and the creation of liability waivers, to ensure project success and compliance in this dynamic environment.

[125] SAFETY AND MEDICAL SUPPORT FOR SPACEFLIGHT EXPERIENCES: BEYOND CERTIFICATION

Jonathan Clark

C2Space, Houston, United States

(Education - Tutorial/Review)

In traditional aerospace activities, medical certification of crew is a key regulatory step. However, in the high-stakes realm of high-altitude and near-space activities, certification is often non-existent. Furthermore, the teams conducting operations are often much smaller, and have more cross-training than traditional commercial aerospace activities; are often in remote environments, and rarely have an established occupational medicine support program. Furthermore, the lines between 'medical' and 'safety' are often blurred, with a complex interplay of medical support, safety, and communication during these missions. Aerospace medical support teams can fill the multifaceted role of ensuring the well-being and safety of extreme environment events in an interdisciplinary fashion, creating communication between operational, engineering, and medical teams. To do so includes providing vital medical support before, during, and after the mission, from training through recovery. For a truly successful strategy, it requires going beyond establishing crucial links with trauma centers, EMS teams, and specialized recovery units; but also extends to fostering a safety-conscious culture, and implementing progressive testing strategies. The emphasis is on a crawl-walk-run approach that avoids unnecessary risks. This presentation will underscore the critical role of safety and medical officer(s), who operate at the nexus of project leaders and crew members. The tension that often arises between them serves as an indicator of the delicate balance required for pushing the boundaries of extreme environment exploration safely. Leveraging lessons learned from multiple stratospheric, hot air balloon, flight operations and clinical medicine, the speaker will normalize the existence of this tension, clarifying that it is not an obstacle but rather a barometer of mission preparedness and safety diligence. Furthermore, the panel will emphasize the significance of proactive risk assessment and communication as a means to mitigate potential dangers, thereby reducing the reliance on near misses or "tasting blood" moments as catalysts for change. By reviewing medical support plans, safety protocols, and communication strategies that have (and have not) been successful, we will impart valuable insights into how to balance innovation with safety in the challenging and dynamic field of spaceflight and other extreme environment missions.

Learning Objectives

1. The audience will be able to describe the different roles of the medical/support team.
2. Participants will gain insight into the diverse responsibilities of medical support, extending beyond crew certification, to ensure the well-being and safety of extreme environment pilots and crew.
3. The panel discussion will provide a deeper understanding of the delicate balance between innovation and safety in extreme environment missions, demonstrating the importance of proactive risk assessment and effective communication to reduce reliance on near misses as drivers for change.

Tuesday, 05/07/2024
Grand Ballroom A

10:30 AM

[S-25]: PANEL: CONNECTING PHYSIOLOGY TO ACCELERATION TOLERANCE

Sponsored by Aerospace Physiology Society

Chair: John Harrell

Co-Chair: Ross Pollock

PANEL OVERVIEW: This panel will present research that explores physiological factors that may contribute to an individual's +Gz tolerance (head-to-foot acceleration). Presentations are focused on topics that probe the physiological mechanisms underlying +Gz tolerance and potential strategies to increase head-level blood pressure, increase cerebral blood flow, and improve +Gz tolerance. The first presentation will describe an effort conducted by personnel at the US Air Force's 711th Human Performance Wing into whether physiological metrics can predict +Gz tolerance. Presentations 2 and 3, also from the 711th Human Performance Wing, will disseminate research on the extent to which arterial and venous characteristics contribute to +Gz tolerance, respectively. In the fourth presentation, researchers from the Royal Air Force Centre of Aviation Medicine will present an assessment of the differing cardiovascular and blood volume responses associated with three distinct levels of G-protection. The final presentation will communicate a collaborative effort between King's College London and the 711th Human Performance Wing investigating the impact of breathing elevated levels of carbon dioxide on cardiovascular and cerebrovascular responses to lower body negative pressure, an analog of hypergravity. This panel is sponsored by the Aerospace Physiology Society.

[126] PHYSIOLOGICAL PREDICTORS OF HIGH G TOLERANCE

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(Original Research)

INTRODUCTION: Exposure to high +Gz puts aircrew at risk for physical and cognitive decline which could lead to fatigue or injury, and ultimately risk mission failures or aviation mishaps. It is important to understand physiological traits associated with G-tolerance to mitigate this risk. Currently, limited associations with G-tolerance have been found and include, age, various anthropometric traits, and some vascular measures. There is a need for more robust test battery to elucidate which traits are associated with +Gz tolerance. **METHODS:** Baseline physiological assessments of human subject panel (HSP) for centrifuge research participants will be conducted (n=100). Measurements include anthropometrics, vascular characteristics, muscular and cardiovascular fitness, training habits, biomarkers and transcriptomics, and HSP training performance. The latter is a phased progression that systematically progresses trainees to full qualification of +9Gz and the ability to conduct simulated aerial combat maneuvers (SACM). Generally, training phases are, +7Gz for 15 seconds (s) reclined seat(R), +9Gz for 15s(R), +7Gz for 15s upright seat(U), +9Gz for 15s (U), +9Gz for 15s(U) plus a SACM in full combat edge. Physiological measurements will be merged with HSP training performance to model physiological associations with G-performance. This study was approved by the Air Force Research Lab institutional review board, protocol: FWR2020048H. **RESULTS:** Analysis of 46 subjects

(fully qualified; 22-males, 4-females; did not qualify (DNQ) 17-males, 3-females) has been conducted. Three (3-males) DNQ at +7Gz for 15s(R), significant association; change in systolic blood pressure (SBP) post activity ($p=0.033$). Ten (9-males, 1-female) DNQ at +9Gz for 15s(R), significant associations; torso length ($p=0.041$) and height ($p=0.045$). Six (4-males, 2-females) DNQ at +7Gz for 15s(U), significant associations; resting SBP ($p=0.047$ and 0.041 for standing and seated respectively), resting diastolic BP ($p=0.011$ and 0.001 for standing and seated respectively), weight ($p=0.014$), and hip girth ($p=0.012$). One male DNQ on the SACM phase, no analysis. **DISCUSSION:** Preliminary analysis suggests there are physiological associations with +Gz tolerance. Once complete, full analyses will be conducted to determine physiological traits separating those successful in HSP training from unsuccessful candidates. Additional analyses will determine traits related to training phase completed.

Learning Objectives

1. Participants will learn about relationships between physiology and +Gz tolerance.
2. Participants will learn about associations between physiology and human centrifuge training.

[127] ARTERIAL STIFFNESS APPEARS IRRELEVANT TO +GZ TOLERANCE

Mikaela Gabler, Andrew Van Der Merwe, Sarah Pfahler, Derek Haas, Molly Wade, John Harrell
 Air Force Research Laboratory - 711 HPW, Wright-Patterson AFB, OH, United States

(Original Research)

INTRODUCTION: Positive acceleration in the head-to-foot axis (+Gz) causes movement of blood to the lower body and limits venous return. A more rigid arterial tree may limit the downward fluid redistribution with increased +Gz. As arterial stiffness (AS) represents the rigidity within arteries to resist wall deformation, this study aimed to determine whether relaxed +Gz tolerance is associated with AS. **METHODS:** 58 healthy individuals (27 ± 5 yr, 8 women) were recruited from the high-acceleration human subject panel maintained at Wright-Patterson Air Force Base. Relaxed and strained +Gz tolerance was measured during gradual onset rate centrifuge exposures (GOR, $0.1 +Gz/s$) without mechanical countermeasures in a 30° reclined seat. Either prior to centrifuge exposure or on a separate day, carotid pulse wave velocity (PWV) was measured in the supine position following 10-min of rest as an indicator of AS. Subsequently, PWV was dichotomized into equal groups for the highest and lowest values (i.e., Low- and High- PWV). Paired T-tests assessed differences between groups. Pearson's correlation analyses evaluated relationships between +Gz tolerance and physiological variables.

RESULTS: Subjects in the Low-PWV group ($p = .001$) were younger ($p = 0.001$) and had lower diastolic blood pressure ($p = 0.018$); however, their relaxed and strained +Gz tolerance were similar to High- PWV ($p > 0.05$). Across all subject groups, men exhibited a negative correlation with relaxed +Gz tolerance ($r = -0.29, p = 0.03$) and taller subjects approached a negative correlation with relaxed +Gz tolerance ($r = -0.24, p = 0.06$).

DISCUSSION: As expected, older subjects and those with higher diastolic blood pressure exhibited greater PWV. Despite greater AS, this did not appear to affect +Gz tolerance. Interestingly, women demonstrated a correlation with relaxed +Gz tolerance, as did shorter height. Whether these factors affect +Gz tolerance in conjunction, or independently, remains to be elucidated. In conclusion, while we show evidence of other physiological factors being related to +Gz tolerance, AS by itself does not appear to be, which may be due to the homogenous nature of our subjects.

Learning Objectives

1. Relaxed and strained +Gz tolerance are not related to arterial stiffness in our sample population.
2. Relaxed +Gz tolerance is correlated with the female sex and shorter height.

[128] VENOUS COMPLIANCE AND +GZ TOLERANCE

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(Original Research)

INTRODUCTION: Positive acceleration in the head-to-foot axis (+Gz) causes movement of blood to the lower body, reducing retinal and cerebral oxygenation. Venous compliance (VC) is the change in venous volume per change in pressure; therefore, less compliant leg veins may limit the downward fluid redistribution that occurs during increased +Gz. This study aimed to determine whether VC is associated with relaxed +Gz tolerance. We hypothesized that VC would be negatively associated with +Gz tolerance. **METHODS:** Thirty-two subjects (28 ± 5yr) participated in the study. Male (n = 24) and female (n = 8) subjects were all active duty members of the United States Air Force. VC was measured using mercury-in-silastic strain gauge plethysmography. A venous occlusion cuff was placed 5cm above the knee and inflated to 60mmHg for 6 minutes. Cuff pressure was then reduced by 1mmHg/s, while calf circumference was recorded. Relaxed and strained +Gz tolerance was measured during gradual onset rate centrifuge exposures (GOR, 0.1 +Gz/s), without mechanical countermeasures, in a 30° reclined seat. Subjects reported loss of 100% of peripheral vision without lower body strain (Relaxed +Gz tolerance) and with lower body strain (Strained +Gz tolerance). Delta +Gz tolerance was calculated as the difference between strained and relaxed +Gz tolerance.

RESULTS: Subjects averaged 4.6 ± 2.6 GOR exposures. Correlation analysis indicated that neither absolute VC ($r^2 = 0.0623$) nor VC slope ($r^2 = 0.0146$) was associated with +Gz tolerance. Subject blood volume ($r = -0.359$, $p = 0.044$) was negatively correlated with +Gz tolerance, with height ($r = -0.335$, $p = 0.061$) and weight ($r = -0.317$, $p = 0.077$) approaching significance. Splitting subjects into Low and High VC groups showed no significant difference in relaxed (4.35 ± 0.52 vs. 4.27 ± 0.43 +Gz, $p = 0.321$), strained (6.11 ± 0.84 vs. 6.27 ± 0.87 +Gz, $p = 0.308$) or delta +Gz tolerance (1.73 ± 0.50 vs. 1.98 ± 0.59 +Gz, $p = 0.117$). **DISCUSSION:** These data indicate a clear relationship between vascular distensibility and +Gz tolerance is absent, and venous compliance alone cannot predict +Gz tolerance. Further research may reveal physiological and physical characteristics that may predict acceleration performance.

Learning Objectives

1. Understand how lower limb venous compliance is measured and analyzed in human subjects.
2. Better understand the relationship between venous compliance, physiological and physical characteristics, and +Gz tolerance in a young military population.

[129] CARDIOVASCULAR AND BLOOD VOLUME RESPONSES TO THREE LEVELS OF G-PROTECTION

Joseph Britton¹, Nicholas Green¹, Stephen Harridge², Ross Pollock²

¹Royal Air Force Centre of Aviation Medicine, Henlow, United Kingdom;

²King's College London, London, United Kingdom

(Original Research)

BACKGROUND: Anti-G Suits provide protection against +Gz acceleration through several physiological mechanisms. The contribution of each of these mechanisms to improving G-tolerance, and how each relate to the degree of protection provided, is not fully understood. This study investigates the cardiovascular response to three levels of G-protection: No (NP), Moderate (MP; 5-Bladder Anti-G Trousers) and Improved (IP; Full Coverage Anti-G Trousers) protection. **METHODS:** 11 subjects

undertook a series of rapid onset (3 G/sec; 15 sec plateau) runs in a human centrifuge with target +Gz increased until Peripheral Light Loss (PLL) was reached. Impedance plethysmography (IPG) assessed blood volume changes in the whole lower body (Total), Abdomen, Thigh and Calf. Non-invasive pressure waveform monitoring was used to calculate Blood Pressure (BP), Cardiac Output (CO), Stroke Volume (SV) and Total Peripheral Resistance (TPR). Heart Rate (HR) was calculated from 3-lead ECG. For each variable, changes between preceding baseline and the +Gz plateau at PLL were analysed using repeated measures analysis and post-hoc pairwise comparisons. A comparison between MP and IP at +3.2 Gz was also performed. **RESULTS:** +Gz at PLL increased with increasing protection (mean ± SD: NP; $+3.4 \pm 0.5$ Gz, MP; $+4.5 \pm 0.6$, IP; $+5.0 \pm 1.0$ Gz). At PLL, there was no difference in the change in eye-level BP, SV or CO between conditions. However, the increase in TPR was greater for IP than MP. At +3.2 Gz, eye-level ΔBP was the same for MP and IP, but ΔHR was higher in MP, whilst ΔTPR was higher in IP. At PLL, Total ΔIPG decreased (i.e blood volume increased) for NP, but changes in individual segments were not significant. Total and Abdominal ΔIPG increased equally with both MP and IP. Thigh ΔIPG increased significantly with IP but was unchanged in the other conditions. Calf ΔIPG was unchanged from baseline in all conditions. At +3.2 Gz, Abdominal ΔIPG was increased more by IP than MP. **DISCUSSION:** At PLL, regardless of the level of protection, key measures of cardiovascular physiology were similar. Greater protection allowed these physiological changes to occur at higher +Gz. Both Anti-G suits reduced blood volume re-distribution to the lower body. The main difference with improved protection was a greater blood volume shift from the thigh. Thigh and abdominal compression appear key to the level of G-protection, whilst calf compression appears less critical.

Learning Objectives

1. The audience will learn about the differences in cardiovascular response between exposures to +Gz with and without G-protection.
2. The audience will learn about how differences in cardiovascular response reflect changes in G-tolerance.

[130] CARBON DIOXIDE INCREASES CEREBRAL BLOOD FLOW DURING LOWER BODY NEGATIVE PRESSURE

Andrew Muriithi¹, Rachel Beri¹, Lail Edelsztejn¹, Ross Pollock¹, John Harrell²

¹King's College London, London, United Kingdom;

²711th Human Performance Wing, Air Force Research Laboratory, Wright-Patterson AFB, OH, United States

(Original Research)

BACKGROUND: Pilots in high-performance aircraft are exposed to acceleration in the +Gz (Head-to-foot) axis which can result in G-induced Loss of consciousness (G-LOC). Breathing elevated levels of CO₂ have been reported to increase Systolic Blood Pressure (SBP) and Middle Cerebral Artery Velocity (MCAv) and therefore may potentially be used to improve G tolerance. Lower body negative pressure (LBNP) has been used as a tool to investigate responses to central hypovolemia and as a surrogate of hypergravity. The present study aimed to determine whether breathing 5% CO₂ increased cerebral blood flow and blood pressure during LBNP. **METHODS:** 15 subjects (9 M/6 F, 31±8 yr) undertook the experiment which involved breathing either room air or a mix of 5% CO₂, 21% oxygen, balance nitrogen for 3 mins followed by a 2 min period of -60mmHg LBNP. There was a 2-minute washout period between trials. We measured middle cerebral artery velocity (MCAv) with transcranial Doppler ultrasound. Continuous, non-invasive blood pressure was measured using finger plethysmograph with mean arterial pressure (MAP), stroke volume (SV), cardiac output (CO) and total peripheral resistance (TPR) determined. We corrected MCAv for blood pressure (MAP) and present it as cerebrovascular conductance index (CVCi). **RESULTS:** LBNP caused an increase in heart rate and TPR while SV and CO significantly

decreased ($p < 0.05$, main effect of LBNP) with each of these changes being similar between breathing gas conditions. MCAv, MAP, and CVCi were all greater during the 5% inspired CO₂ trials ($p < 0.05$, main effect of gas), irrespective of exposure to LBNP. **DISCUSSION:** Breathing a mixture of 5% CO₂ increased cerebral blood flow and blood pressure with these increases remaining during an analogue of hypergravity. While technical challenges exist in integrating CO₂ breathing inflight, increasing inspired CO₂ could contribute to better G-tolerance.

Learning Objectives

1. The audience will note that breathing a mixture of 5% CO₂ increased cerebral blood flow and blood pressure, and these increases were demonstrated in an analogue of hypergravity.
2. The audience will learn that increasing inspired CO₂ could contribute to better G tolerance.

Tuesday, 05/07/2024
Grand Ballroom B

10:30 AM

[S-26]: PANEL: GENDER DYSPHORIA - THE USAF WAIVER PROCESS

Chair: Ryan Peirson

PANEL OVERVIEW: *Body: This panel discusses the USAF Aeromedical Consultation Service's (ACS) experience of evaluating transgender aircrew. It starts with a definition of Gender Dysphoria and its implications in the aerospace environment as well as a brief discussion about the enduring controversy associated with the nomenclature. The process and challenges of the USAF's Waiver system for Gender Dysphoria are then described. The history and changes in terms related to Gender Dysphoria are also covered. The panel examines the psychological profiles of evaluatees and presents ACS procedures and experiences. The goal of the panel is to provide a clear understanding of the intersection between Gender Dysphoria, the USAF's aeromedical standards, and the evaluation process.*

[131] GENDER DYSPHORIA: USAF WAIVER GUIDE AND PROCESS

Kevin Heacock

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Gender Dysphoria is a medical condition characterized by a marked incongruence between an individual's experienced gender and their assigned sex at birth. Those with Gender Dysphoria may experience distress related to this incongruence, which can manifest in various ways. Gender Dysphoria, like other medical conditions, can be managed with appropriate care and is eligible for flying waiver following clinical stability. **TOPIC:** Receiving a waiver to fly in the United States Air Force (USAF) after being diagnosed with Gender Dysphoria involves a comprehensive process. First and foremost, individuals diagnosed with Gender Dysphoria must prioritize their health and follow the prescribed medical treatment plan, which may include hormone therapy or gender-affirming surgery. Once they are found to be clinically stable, they can proceed with the waiver application. The waiver process starts with thorough documentation of their medical history, including records of their Gender Dysphoria diagnosis and treatment. This documentation should demonstrate their commitment to health and stability. It's crucial to provide detailed information about the management of Gender Dysphoria and any accompanying mental health care. **APPLICATION:** Aerospace medicine plays a pivotal role in evaluating individuals seeking a waiver for aviation duty in the USAF. The USAF's Medical Standards Directory identifies all diagnoses with an F-Prefix in the current version of the Diagnostic Statistical Manual of Mental Disorders (DSM-5-TR) as disqualifying for flying duties. Gender Dysphoria is one of these F-Prefix diagnoses and so requires a waiver to return to flying status. The waiver

process looks for the successful management of Gender Dysphoria as well as the ability to manage the demands of the aerospace environment. This includes demonstrating the ability to maintain mental and emotional stability under high-pressure aviation conditions. The waiver process recognizes that individuals with Gender Dysphoria can contribute effectively to the mission while ensuring their well-being and readiness for flying duties. **RESOURCES:** 1. American Psychiatric Association (Ed.). (2022). *Diagnostic and statistical manual of mental disorders: DSM-5-TR* (Fifth edition, text revision). American Psychiatric Association Publishing. 2. CLEARED on 25 Oct 2023 - PAIRS CASE 2023-0957/AFRL-2023-4926.

Learning Objectives

1. Comprehend the Waiver Process for Gender Dysphoria in the USAF: Gain an understanding of the comprehensive process involved in obtaining a waiver to fly in the United States Air Force (USAF) after being diagnosed with Gender Dysphoria, including the importance of clinical stability and the required medical documentation.
2. Evaluate the Role of Aerospace Medicine in Aviation Waivers: Explore the pivotal role of aerospace medicine in evaluating individuals seeking a waiver for aviation duty in the USAF. Understand the specific medical standards and disqualifying criteria as outlined in the DSM-5-TR, and their implications for returning to flying status.

[132] GENDER DYSPHORIA: DEFINITIONS AND IMPLICATIONS IN THE AEROSPACE ENVIRONMENT

Terry Correll

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: In adolescents and adults dealing with gender dysphoria, there is often a mismatch between their experienced gender and their physical sex characteristics. This disconnect may or may not be accompanied by a strong desire to eliminate certain primary and/or secondary sex characteristics or an eagerness to acquire corresponding features of a different gender. Older adolescents and adults with gender dysphoria may, to varying degrees, adopt the behaviors, clothing, and mannerisms associated with their experienced gender, and they often experience discomfort when perceived or treated as members of their assigned gender in society. Self-identification as transgender is reported in the range of 0.5% to 0.6%, while experiencing an incongruent gender identity is seen in 0.6% to 1.1% of individuals. Feeling like a person of a different sex is reported by 2.1% to 2.6% of the population, and the desire to undergo medical treatment falls within the range of 0.2% to 0.6%. In adults, studies generally indicate that more individuals assigned male at birth seek gender-affirming treatment, with ratios ranging from 1:1 to 6.1:1 in most research conducted in the United States and Europe. **TOPIC:** The potential aeromedical implications are concerning. Gender nonconformity may affect peer relationships and may lead to isolation from peer groups and to distress. Gender dysphoria is associated with high levels of stigmatization, discrimination, and victimization, leading to negative self-concept, increased rates of depression, suicidality, and other mental disorder co-occurrence, school dropout, and economic marginalization, including unemployment, with attendant social and mental health risks, especially in individuals who lack family or social support. Individuals who have experienced harassment and violence may also develop posttraumatic stress disorder. Rates of suicidality and suicide attempts for transgender individuals are reported to range from 30% to 80%. **APPLICATION:** We will discuss important aspects of the aeromedical evaluation to assure that the transgender flyer is ready for waiver submission, safe flying, and is capable to fully function and complete their assigned mission. **RESOURCES:** 1. American Psychiatric Association (Ed.). (2022). *Diagnostic and statistical manual of mental disorders: DSM-5-TR* (Fifth edition, text revision). American Psychiatric Association Publishing. **Learning Objectives**

1. We will discuss the potential aeromedical implications in individuals with gender dysphoria.

2. The potential associated psychopathology with gender dysphoria will be reviewed.
3. We will examine important aspects of the aeromedical evaluation to assure that the transgender flyer is ready for waiver submission, safe flying, and is capable to fully function and complete their assigned mission.

[133] PSYCHOLOGICAL AND NEUROPSYCHOLOGICAL ASSESSMENT IN GENDER DYSPHORIA

Monica Malcein

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Estimates of gender nonconformity range from 0.5% to over 1% in US samples. Gender dysphoria refers to psychological distress from an incongruence between one's sex assigned at birth and one's gender identity. Research suggests increased risk for co-morbid psychiatric diagnoses in those with gender dysphoria. Some transgender persons undergo gender transition treatment, which may include hormone therapy and/or undergoing medical procedures. For many, gender-affirming treatment results in reduced psychological distress. Treatment with hormones can also result in other emotional and mental/cognitive changes that are not well characterized. Psychological and neuropsychological assessment of individuals with Gender Dysphoria is part of an evaluation for waiver recommendation, although there are particular challenges for assessment in this group. The availability of appropriate normative data is extremely limited and use of assessment measures with gender norms can be problematic. **TOPIC:** Given the potential comorbid psychosocial issues and psychiatric diagnoses in those with a history of Gender Dysphoria, post-transition transgender pilots and aircrew are evaluated at the ACS. This evaluation includes clinical interviews with psychiatry and psychology, psychological/personality assessment, and intellectual/neurocognitive testing. A total of 14 flyers have been evaluated at the ACS for Gender Dysphoria. Most are male to female transition (71%). All were administered MAB-II, MicroCog, MMPI-2-RF, and NEO-PI-3. We present qualitative findings of these measures to explore the usefulness of psychological testing data in this population. Additionally, we address potential aeromedical implications and provide some recommendations for navigating the challenges in assessment of this unique population.

APPLICATION: Gender Dysphoria is disqualifying for flying duties in the USAF, but a waiver may be considered for flying if stability can be documented. Comprehensive assessment, with the inclusion of objective measures of neurocognitive and psychological functioning can be useful, although there are several factors to consider when using assessment instruments that have not been normed or validated on the transgender population. Findings from the series of evaluations of those with Gender Dysphoria at the ACS are provided to highlight the usefulness of these measures and inform future assessments in this population.

Learning Objectives

1. The audience will have a greater understanding of Gender Dysphoria among aviation population.
2. The learner will be briefed on the challenges on psychological and neuropsychological assessment in gender nonconforming individuals.
3. Assess the usefulness of psychological and neuropsychological testing data in the evaluation of aircrew with Gender Dysphoria.

[134] GENDER DYSPHORIA – THE USAF WAIVER PROCESS

Henrik Close

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: The diagnosis of gender dysphoria has specific requirements per the psychiatric diagnostic manual. This presentation will elaborate upon these criteria and use an anonymized example

patient case as a demonstration. **TOPIC:** One case representing an example of a gender dysphoria presentation will be discussed. Particular attention will be given to the application of diagnostic criteria for the condition, as well as the childhood and young adult experiences reported by our patient that contributed to the recognition of this condition. This discussion will build on the earlier panel presentations and highlight the ACS' experience as well as observations about trends within the cohort. **APPLICATION:** The discussion will be applicable primarily to U.S. Air Force flight surgeons and mental health providers. The concepts and process may be interesting to those administering waivers and or treating flyers in other military services and in civil aviation. **RESOURCES:** 1. American Psychiatric Association: Diagnostic and Statistical Manual of Mental Disorders: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision. 2. U.S. Air Force Aeromedical Waiver Guide

Learning Objectives

1. The participant will be able to analyze and interpret a case study representing an individual with gender dysphoria, applying the diagnostic criteria to understand their condition.
2. The participant will be able to discuss the childhood and young adult experiences that may contribute to the recognition of gender dysphoria in individuals, using the anonymized case study as an example.

Tuesday, 05/07/2024

Grand Hall J

10:30 AM

[S-27]: SLIDES: OCCUPATIONAL STRESSORS ON BEHAVIORAL/MENTAL HEALTH

Chair: Steve Vanderark

Co-Chair: Karen Keats

[135] IMPACT OF OCCUPATIONAL STRESSORS ON THE MENTAL HEALTH OF RPAS OPERATORS

Tooba Tahir

RAF, Lincolnshire, United Kingdom

(Education - Program/Process Review)

BACKGROUND: Military Remotely Piloted Aircraft Systems (RPAS) are used for surveillance, reconnaissance and weapon-strike operations. They are controlled by operators, often thousands of miles away from the combat zone. This results in unique occupational stressors. The visual and auditory data from real-time missions can lead to exposure of traumatic stimuli. Personnel exposed to combat zones are at an increased risk of developing PTSD and burnout. For RPAS operators, this can lead to incidents within flight. This review was carried out to determine which occupational stressors exist and the impact on mental health in RPAS operators. **OVERVIEW:** A systematic literature review was conducted across three databases: Pubmed, Scopus and API PschInfo using variants of the search terms "RPAS" and "mental health" and "aircrew". 18 papers were included, all of which were original studies. Two main stressors were identified: 1) operational stressors 2) combat stressors. **DISCUSSION:** RPAS operators were not at an increased risk of mental health problems compared with other military personnel exposed to combat scenarios. Prevalence of disorders, including PTSD were low. However, symptoms were still present despite not meeting threshold criteria for diagnosis. 70% of RPAS operators reported functional impairment due to this and 14-26% described high levels of exhaustion and burn out. Variables increasing risk of PTSD included working greater than 51 hours a week and working for over 2 years at a station. Trouble sleeping and difficulty concentrating were amongst the most common symptoms expressed. Fatigue can impact cognition, increases risk of errors and degrades performance. This can compromise operational effectiveness and safety at a national and global level. The risk of PTSD was increased by combat

stressors including witnessing the impact of enemy forces on civilian bystanders. Within the UK and US, the biggest contributor for occupational stress were self-reported operational factors including long working hours and shift patterns. Due to the studies using self-reporting methods by the operators, it is possible that under-reporting of mental health issues may affect the accuracy of the picture. Recommendations to reduce occupational stressors include supportive outreach by psychiatric teams and leadership involvement to implement meaningful change.

Learning Objectives

1. Learn about which factors lead to an increase in occupational stress for RPAS operators.
2. Understand the impact of occupational stressors upon the mental health of RPAS operators and recommendations to reduce this.

[136] COGNITIVE WORKLOAD MANIPULATION WITH THE COGNITIVE ASSESSMENT OF AVIATION PERFORMANCE AND EVALUATION OF STATE

Andrew Dorsey¹, Jeffrey Phillips¹, Emily Bowers¹, Arnold Henry¹, Ryan Mayes²

¹Florida Institute for Human and Machine Cognition, Pensacola, FL, United States; ²USAFSAM, Dayton, OH, United States

(Original Research)

INTRODUCTION: High cognitive workload can be a significant hazard for operators in extreme environments. Environmental stress and task saturation often compound to negatively affect cognitive performance leading to a loss of situational awareness and mistakes, yet these effects can be transient and more difficult to measure. The U.S. Air Force School of Aerospace Medicine (USAFSAM) Cognitive Assessment of Aviation Performance and Evaluation of State (CAAPES) is a neuropsychological tool developed to rapidly detect operationally representative cognitive performance effects resulting from common aeromedical stressors. CAAPES also facilitates the ability to manipulate workload by adding or subtracting subtasks to create low and high workload conditions in concert with environmental stressors. This presentation explores CAAPES as a tool to manipulate workload effects across two independent studies and will discuss its application across multiple methodologies to explore the interaction between environmental stress and cognitive workload state. **METHODS:** Both studies were conducted at the Florida Institute for Human and Machine Cognition (IHMC) and approved by the IHMC and Naval Medical Research Unit-Dayton Institutional Review Board. In Study I participants ($n = 10$) from the general population performed each separate component of CAAPES alone and in all possible combinations. Participants rated their subjective cognitive workload with the NASA-TLX after each unique iteration. Study II ($n = 16$) recruited Student Naval Aviators from Naval Air Station Pensacola to perform CAAPES in both high and low workload conditions every 30 minutes across a six-hour period while either under a placebo or diuretic induced state of dehydration. **RESULTS:** Study I indicated a 16.4 increase in subjective mental workload between low and high workload and the ICCs performed on CAAPES Composite formulas all revealed values ($>.80$). Study II revealed a statistically significant performance effect for tracking across workload conditions ($F(1, 13) = 58.05, p < 0.05, \eta^2 = 0.817$).

DISCUSSION: These findings demonstrate that CAAPES can reliably manipulate workload to facilitate investigations into workload by stressor interaction effects. Further research is warranted to understand the role of cognitive workload in performance effects associated with a variety of physiological stressors; CAAPES appears to be a valuable tool in understanding this complex interaction.

Learning Objectives

1. Learn how CAAPES facilitates the manipulation of cognitive workload by adding or subtracting subtasks to create low and high workload conditions.
2. Understand workload effects may impair performance in unexpected circumstances rather than routine scenarios when combined with physiological stressors, such as hypoxia, hypercapnia, or dehydration.

3. Appreciation for the need for further research in scenarios where cognitive workload may impede performance under a variety of physiological stressors.

[137] REALITY CHECK: OVERVIEW OF PILOT STRESSORS, BACKED UP BY RECENT HEADLINE-MAKING INCIDENTS

Marion Venus

Venus-Aviation Research, Training & Pilot Support, Zurich, Switzerland

(Original Research)

INTRODUCTION: This study examined multiple stressors pilots face on duty in the high-risk high-reliability system aviation. While aviation is promoted as extremely safe, many for pilots successfully managed stressful, potentially dangerous incidents, which recently made headlines.

METHODS: More than 400 international pilots completed a cross-sectional online survey, which assessed psychosocial stress (PHQ-Stress) and work-related stressors like little experience, job-insecurity, short rest-periods, long working-hours, etc. Pilots' mean age was 40.93 ± 10.62 years ($M \pm SD$), 70% of the pilots reported flying short haul, 30% long haul, 8% pilots were female. The pilots' comments regarding stressors were analyzed with a Qualitative Content Analysis (QCA). The results were listed and correlated with real recent aviation incidents, which made headlines.

RESULTS: Professional pilots reported on average 116.9 ± 41.2 duty hours in the last month. Pilots reported multiples stressors like irregular shift work, physiologist stressors like roster-related sleep-deprivation, psychological and psychosocial stressors, as well as work-related and existential pilot-specific stressors or threats. **CONCLUSIONS:** The extent of stress for pilots has been largely ignored and underestimated in recent years. When air operators strive for and achieve maximum productivity, this has negative effects on the stress and health of pilots. Even if aviation is still described as the safest transport medium, stress and, as a result, fatigue not only endanger flight safety, but also the psychological and physical health of pilots. Many headlines about stressful or even life-threatening events in flight make it clear that pilots are justifiably worried about their own safety and flight safety, which also puts a lot of strain on their mental health.

Learning Objectives

1. Participants will learn about different types of stressors for pilots, as pilots perceive them.
2. Participants will learn about recent stressful or life-threatening incidents, which represent job-related stressors for all pilots.

[138] INFLUENCE OF OLFACTORY VIRTUAL REALITY ON BEHAVIORAL HEALTH

Renee Abbott, Ana Diaz-Artilles

Texas A&M University, College Station, TX, United States

(Original Research)

INTRODUCTION: Isolation and confinement place astronauts at higher risk for developing adverse behavioral health conditions and many current psychological countermeasures are ill-suited for future exploration missions. Virtual reality (VR) technologies could promote relaxation by providing astronauts with a means to experience nature, which has been shown to have numerous psychological and physiological benefits. Creating a fuller, multisensory VR experience could further enhance these benefits. **METHODS:** We conducted an experiment to investigate the use of olfactory stimuli in nature-inspired VR environments. This was a within-subjects (7M/3F), counterbalanced design comparing the effects of a control condition (VR only) to the intervention condition (VR + scents). First, participants completed a public speaking task to elicit a stress response. Then, subjects had 15 minutes to freely explore the VR environment. This was repeated for the other VR condition. The Positive and Negative Affect Schedule (PANAS) and the 6-item State-Trait Anxiety Inventory (STAI-6) were used to evaluate mood and anxiety levels. These

surveys were administered before the stressor (baseline, T1), after the stressor (T2), and after the VR intervention (T3). **RESULTS:** In the VR + scents condition, negative affect ($p < 0.01$) and anxiety ($p < 0.001$) scores significantly decreased from T2 to T3. Anxiety scores were also significantly lower after the VR intervention (T3) than at baseline (T1) in the VR + scents condition only ($p < 0.05$). Positive affect did not change over the duration of the experiment for either condition. **DISCUSSION:** We hypothesize that recruiting more sensory modalities increased immersion and presence in the VR environment, resulting in a decrease in subjective negative affect and anxiety after exposure. Qualitative feedback also indicated that some participants liked/disliked different scents and aspects of the VR environment, highlighting the importance of personalization in psychological countermeasures. Our ongoing work will examine the effect of our VR intervention over a longer period (several weeks) and will allow the user to choose between several different VR environments. We are also adding other somatosensory components simulating temperature changes and wind to further increase immersion, and we are expanding to include physiological measures and cognitive performance.

Learning Objectives

1. The audience will understand that creating multisensory experiences can enhance the psychological benefits of relaxing VR environments.
2. The audience will understand that psychological countermeasures should employ aspects of personalization to maximize effectiveness.

[139] ATTENTIONAL TUNNELING IN PILOTS DUE TO A VISUAL TRACKING TASK WITH A HEAD MOUNTED DISPLAY

Wietse Ledegang¹, Erik Van der Burg², Frank Kooi¹, Mark Houben¹, Eric Groen¹

¹TNO, Soesterberg, Netherlands; ²University of Amsterdam, Soesterberg, Netherlands

(Original Research)

INTRODUCTION: It is known that presentation of symbology as a visual overlay may draw attentional resources away from other tasks, which is called 'attentional tunneling'. Moreover, actively aiming one's head, to keep Helmet Mounted Display (HMD) symbology aligned with an external target object, may also draw the pilot's attention away from the primary flying task. In a simulator study, we investigated the impact of active head aiming on an attitude control task while flying in clouds. Furthermore, we examined the effects of additional visual clutter on both head aiming and attitude control. **METHODS:** Eighteen pilots, with military flying experience, conducted the experiment in a generic fixed-base fighter simulator with a dome projection and head-slaved projection of HMD-symbology in the out-the-window visuals. The pilots' task was to continuously compensate a roll disturbance while actively aiming a head-referenced circle to a moving visual target. The diameter of this circle and amount of visual clutter were varied. Each run consisted of a small magnitude roll disturbance phase, sustained roll 'run-away' and high magnitude roll disturbance phase. Control inputs, roll angle, head direction and subjective measures were collected. The experiment was conducted with approval of the institutional ethics committee in accordance with the (revised) Helsinki Declaration. **RESULTS:** The results show that, when flying in clouds, the attitude control task deteriorated with increasing difficulty of the head aiming task. Vice versa, head aiming accuracy was worse in the high disturbance phase. Subjective ratings indicated that both tasks influenced each other equally. Besides control accuracy, active head aiming also increased the chance of roll-reversal errors. Although the subjects subjectively indicated that clutter was disturbing in the head aiming conditions, it had no significant effect on the objective performance measures. During the roll 'run-away', the subjects showed delayed response and more roll-reversal errors in the difficult head aiming condition. **DISCUSSION:** The results show that, while flying in clouds, active head aiming of HMD symbology causes attentional tunneling, leading to less accuracy on a simultaneously performed attitude control task representative of aircraft control. Also, head aiming may increase the risk for unrecognized spatial disorientation.

Learning Objectives

1. The audience will learn about the increased risk of attentional tunneling in pilots due to a visual tracking task with a head mounted display.
2. The audience will learn that head aiming may increase risk for unrecognized spatial disorientation.

[140] THE EFFECTS OF CO₂ ON EXECUTIVE AND NON-EXECUTIVE FUNCTION, BOHR EFFECT, AND YERKES-DODSON LAW

Jeffrey B. Phillips, Bowers Emily, Andrew Dorsey, Henry Arnold
Florida Institute for Human and Machine Cognition, Pensacola, FL, United States

(Original Research)

INTRODUCTION: Military divers and tactical aviators face numerous environmental hazards making each operation a calculated risk. Hypercapnia, elevated CO₂ in the arterial blood (PaCO₂), is one of the stressors that can result in impairments in operator neurological status, increase the probability of an accident and present a significant risk to the operator. The following two studies explore the direction and magnitude of the effect of low-level exposures to CO₂ on tracking performance (TP), reaction time (RT) and executive function (EF). **METHODS:** Study 1: Thirty-five active-duty Student Naval Aviators (SNAs) ($M = 24.11$ years, $SD = 2.14$) performed two iterations of the Cognitive Assessment of Aviation Performance and Evaluation of State (CAAPES), while breathing four normobaric CO₂ concentrations, 1.0%, 2.5%, 4.0%, 5.5%, delivered via an MBU-20/P flight mask, for 15-minutes in each condition. Study 2: Twenty-five active-duty (SNAs) ($M = 23.36$ years, $SD = \pm 1.68$) performed either two or three iterations of a Stroop Task and a Go/No-Go Task while breathing normobaric CO₂ concentrations, 0.04%, 1%, 2.5%, and 4%, delivered via Interspiro MKII Divisor Mask for 15 minutes in each condition. **RESULTS:** Transcutaneous (PaCO₂) increased in participants across all four of their respected CO₂ exposures. The ANOVA conducted on the tracking component of CAAPES without the subtasks showed, $f(1.69, 28.78) = 4.39, p = 0.027, \text{partial } \eta^2 = 0.21$. TP peaked at 4.0% CO₂. Repeated Measures ANOVA of the Stroop Effect RT scores showed a significant effect, $(F(3, 72) = 3.494, p = .020)$. Participants Stroop accuracy percentage showed no effect, $(F(72, 3) = .319, p = .812)$. A Repeated Measures ANOVA of average number of failed "No-Go" responses showed no effect, $(F(69, 3) = 1.106, p = .353, \eta^2 = .046)$. RT Performance Peaked at 2.5% and 4.0% CO₂. **CONCLUSION:** The stimulating and arousal effects of CO₂ significantly improved TP on CAAPES and RT on Stroop and Go/No-Go. CO₂ exposure did not negatively affect EF as measured by Stroop and Go/No-Go. Across all metrics high PaO₂ conditions were associated with better performance as predicted by the Yerkes-Dodson Law and the Bohr Effect.

Learning Objectives

1. Why is CO₂ a common stressor divers and aviators face operationally?
2. How executive and non-executive function cognitive processing is affected by CO₂.
3. How CO₂ affects performance through the Yerkes Dodson Law and the Bohr Effect.

Tuesday, 05/07/2024
Grand Hall K

10:30 AM

[S-28]: PANEL: RESIDENT IN AEROSPACE MEDICINE (RAM) GRAND ROUNDS I

Chair: Robert Haddon

Co-Chairs: Sonya Heidt, Jonathan Elliot

PANEL OVERVIEW: Clinical case presentations by residents and fellows

[141] This abstract was moved to S-52.

[294] THE INFLUENCE OF NAVAL FLIGHT STATUS REGARDING THE TREATMENT OF A CERVICAL CHAIN SCHWANNOMA

Matthew Lindsey

Naval Aerospace Medical Institute, Pensacola, FL, United States

(Education - Case Study)

Naval Aviators often make health-related decisions that better enable them to fly. A recent study indicated that aviators were more likely to report medical conditions that have a lower propensity for grounding such as dermatological conditions. Naval aviators may also undergo medical procedures that enable them to fly through their medical qualification process. This has been seen often in receiving laser surgery to meet vision qualifications. However, there are other cases in which treatment decisions are influenced by the perceived necessity to fly in the operational setting. This can be seen in the case of a Cervical Sympathetic Chain Schwannoma. This report noted that an asymptomatic patient presented for a flight physical with a persistent lump on the left side of his neck. After a workup, the mass resulted in a cervical chain schwannoma measuring 2.4 x 1.7 x 3.3 cm posterior to the left carotid and jugular vein deep to the sternocleidomastoid. Cervical chain schwannomas are uncommon benign nerve sheath tumors that often present as an asymptomatic solitary neck mass. Surgical excision can be a treatment of choice for these tumors. However, the Naval Aerospace Medicine Institute (NAMI) otorhinolaryngology department chair recommended a conservative approach of observation since these tumors tend to be slow-growing. Given both options, the aviator chose to have surgery despite the risk of Horner's syndrome following surgery which, if prolonged, may be disqualifying in aviation. The aviator's reasoning was to save himself time, opportunity cost, and career investment in the Naval aviation community should observation result in needed surgery later which could be disqualifying. The more immediate surgery he elected to undergo did result in the expected surgical complications of Horner syndrome symptoms of ptosis and miosis without anhidrosis. Fortunately, Horner's syndrome resolved and had no impact on his vision. Ultimately, he was able to resume flight training with minimal grounding time. This case illustrates that Naval Aviators may be more willing to undergo procedural risk for the ability to fly.

Learning Objectives

1. Describe how pathology of the cervical chain schwannoma affects the aviation environment.
2. Describe how flight status may determine the Naval Aviators' medical decision-making.
3. Describe the pathophysiology, epidemiology, symptoms, diagnosis, and methods of treatment for a cervical chain schwannoma.

[142] CROHN'S DISEASE IN A HIGH-PERFORMANCE AIRCRAFT PILOT: A CASE FOR THE AEROMEDICAL CONSULTATION SERVICE MEDICAL RISK ASSESSMENT AND AIRWORTHINESS MATRIX

Preston Moore, Noel Colls, Victor Parker

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case report describes a high-performance aircraft pilot who presented with chronic fatigue, was found to be anemic, diagnosed with Crohn's disease, and eventually returned to flying status. **BACKGROUND:** Crohn's disease is a bowel disorder characterized by transmural inflammation that may affect any portion of the gastrointestinal tract from oral cavity to perianal area. Crohn's disease affects 422 people out of 100,000 in North America, and, with an age of onset between 15 and 30 years, is likely to affect pilots after becoming trained assets. For this reason, evidence-informed aeromedical decision making is critical for maintaining safety of flight and ensuring mission completion. **CASE PRESENTATION:** The subject of this case report was an experienced high-performance

aircraft pilot who initially presented with a complaint of chronic fatigue. Evaluation of this complaint found anemia. Upon further workup, the subject was diagnosed with Crohn's disease. After surgical resection of his terminal and distal ileum and stabilization on adalimumab, the subject was initially returned to flying status with a waiver for ejection seat aircraft with two pilots. Subsequent demonstrated stability and flight safety allowed for upgrade to an unrestricted waiver. **DISCUSSION:** This case highlights the importance of evidence-informed aeromedical decision making with Crohn's disease. Crohn's disease is a non-curable illness with a relapsing-remitting course and the potential for both intestinal and extra-intestinal complications and is thus considered disqualifying for all flying classes. Up to 20% of patients with Crohn's disease experience prolonged remission after initial control and 50% have intestinal complications at 20 years, though this is more likely with certain risk factors such as perianal or rectal involvement. However, those adequately treated and in remission are less likely to develop complications. There is little published aeromedical literature, yet one case series has shown long-term flight and operational safety in pilots with Crohn's disease. In this light, the USAFSAM Aeromedical Consultation Service Medical Risk Assessment and Airworthiness Matrix provides a mechanism to apply the evidence in each clinical situation to inform aeromedical risk assessments and decisions to return trained assets to flying status.

Learning Objectives

1. The participant will be able to understand the aeromedical implications of Crohn's disease.
2. The participant will be able to understand how to apply the USAFSAM Aeromedical Consultation Service Medical Risk Assessment and Airworthiness Matrix in aeromedical decision making.

[143] DIAGNOSTIC ASSESSMENT OF HIGH ALTITUDE-INDUCED HYPOXEMIA

Wiaam Elkhatab¹, Jan Stepanek², Bruce Johnson¹, Michael Wolf¹

¹Mayo Clinic Rochester, Rochester, MN, United States; ²Mayo Clinic Arizona, Scottsdale, AZ, United States

(Education - Case Study)

INTRODUCTION: This report discusses the diagnostic approach for a case of recurrent, subacute symptomatic hypoxemia at high altitude. **BACKGROUND:** Millions of people visit extreme altitudes via air travel and mountaineering. High altitude can elicit symptomatic hypoxemia via compensatory adaptations and in those with underlying cardiopulmonary or hematologic conditions. **CASE PRESENTATION:** A 71-year-old healthy retired male pilot presented for subacute dyspnea with oxygen saturations below 80% at altitude, headaches, and anxiety. Symptoms were discordant with altitude and evolved from previous nominal tolerance. Cardiology, pulmonology, hematology, and sleep medicine consults are obtained. Cardiopulmonary exercise stress testing, 12-lead resting electrocardiography, pulmonary function tests, positional pulse oximetry, right heart catheterization, chest x-ray, computed tomography with angiography assessing hepatopulmonary vasculature, and hemoglobinopathy work up with comprehensive metabolic laboratory studies were obtained, though in this case largely unrevealing. Additional high-altitude simulation testing, resting arterial blood gas, and overnight oximetry near sea level confirmed moderate hypoxemia. Non-obstructive coronary disease via imaging and trivial patent foramen ovale via transthoracic echocardiogram with shunt study were incidentally noted. Focused testing should be repeated at or above symptomatic altitude including pulse-oximetry, arterial blood gas, overnight sleep oximetry and transthoracic echocardiography with shunt study. Central versus peripheral hypoventilation were suspected, with differential etiologies considered including age-related changes, hyper-acute emergent conditions, altitude illness, metabolic, structural and functional cardiopulmonary, physiologic and anatomic vascular shunting, ventilation/perfusion mismatch, and normal physiologic adaptation. Diagnostic findings guide management. **DISCUSSION:** The risks, diagnoses, and outcome management of discordant symptomatic hypoxemia following high-altitude exposure are highlighted and reviewed through this case report. Developing a broad differential with

comprehensive algorithmic approach facilitates diagnosis and guides treatment or countermeasures for medical providers. This report illustrates imperative considerations for preserving health and mission-capability when presented with complex patients, pilots, and military personnel affected by extreme altitude environments.

Learning Objectives

1. Understand the clinical algorithmic approach to altitude-induced hypoxemia and the relative strengths and utility of varying diagnostic tests available.
2. Evaluate the broadened differential diagnostic considerations for clinically confirmed significant hypoxemia presenting with discordant symptomatology.
3. Recognize the arterial blood gas as an under-utilized clinical test for guiding diagnosis and potential etiology of symptomatically discordant non-invasive oxygen desaturations.

[144] SIMPLE SHOULDER SYMPTOM SIGNALS SOMETHING SINISTER IN SHUTTLE SPACEWALKER

Rebecca Mendelsohn, Jeffrey McBride

UTMB, Galveston, TX, United States

(Education - Case Study)

INTRODUCTION: This case report describes a Shuttle-era astronaut, who completed a ground-breaking spacewalk while suffering from symptomatic Parkinson's Disease. **BACKGROUND:** Parkinson's Disease is a progressive disorder of the central nervous system (CNS), which has profound impacts to both cognitive functioning and motor skills in its later stages. Rarely diagnosed in the early stages, patients with Parkinson's Disease are often profoundly symptomatic, with tremors, unstable gaits, slowed movements, stiff body posture, and even difficulty swallowing.

CASE PRESENTATION: A male astronaut in his mid-40s presented to Johnson Space Center's Flight Medicine Clinic for a routine physical. After an otherwise normal exam, the astronaut described experiencing decreased arm movements while walking, which he attributed to a shoulder injury from racquetball. Upon completion of a thorough neurological evaluation, the astronaut was diagnosed with Parkinson's Disease. This particular astronaut had already successfully completed multiple Shuttle missions, and was subsequently scheduled to perform a complex extra-vehicular activity (EVA) during an upcoming flight. In working with his neurologist and the flight surgeons at JSC, he successfully completed his mission and the EVA with no untoward effects from his Parkinson's diagnosis. **DISCUSSION:** After a critical diagnosis, this astronaut was able to complete an arduous, mission-critical, and historic EVA despite experiencing the psychomotor impacts of a degenerative neurological disease. By collaborating closely with the astronaut, his neurologist, the trainers at the Weightless Environment Training Facility (WETF), and NASA leadership, flight surgeons were able to monitor his progress and ensure that the astronaut would have a safe and successful mission without prematurely terminating a vibrant career.

Learning Objectives

1. After this presentation, learners will be able to recognize the early symptoms of Parkinson's Disease in an astronaut and will understand early treatment and mitigation approaches.
2. After this presentation, learners will have a better understanding of the complexities of aeromedically certifying individuals with progressive neurological disorders to perform mission-critical tasks during spaceflight.

[145] RABIN CONE CONTRAST TESTING: A DEMONSTRATION OF TRUE COLORS

Erica Murray, LTC Sonya Heidt

U.S. Army Medical Center of Excellence (MEDCoE), Fort Novosel, AL, United States

WITHDRAWN

[146] TYPE II DECOMPRESSION SICKNESS IN A PARACHUTIST DISPATCHER

Ian McIver

Naval Aerospace Medical Institute, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: This case report describes a parachutist dispatcher who experienced type ii decompression sickness following repeated high-altitude exposure. **BACKGROUND:** During military parachute operations the aircraft must depressurize prior to disembarking jumpers and equipment. This exposes not only the jumpers but also parachutist dispatchers, the aircrew responsible for conducting jump operations, to decreased atmospheric pressure. At altitudes greater than 18,000 ft there is a risk of developing decompression sickness. The physically demanding process of dispatching jumpers and their equipment places parachutist dispatchers at increased risk. **CASE PRESENTATION:** The subject was a 36-yr old male Royal Air Force parachutist dispatcher aboard a C-130. He was considered competent and qualified for the jump operations that were being conducted and had successfully carried out similar operations previously. RAF guidance for high altitude exposure limitations and mitigation were followed. The incident occurred during a series of high altitude jump training operations. The crew completed the required denitrogenation period prior to depressurizing the aircraft. The aircraft was depressurized for 40 min at 25,000 ft. The crew remained on oxygen during the offload process. Shortly after landing he reported pain in multiple joints, paresthesia, a headache, blurred vision and mental fog. Other members of the aircrew reported his speech became difficult to understand and he vomited. Based on symptoms and altitude exposure he was diagnosed with decompression sickness. Due to his neurological symptoms this was classified as type ii. He was treated in a hyperbaric chamber per US Navy treatment table 6 resulting in resolution of his symptoms. On reevaluation the next day he reported difficulty recalling these events. **DISCUSSION:** Decompression sickness remains a significant hazard in the aviation environment. A thorough history, including detailed information on recent flight profiles is vital in the diagnosis of decompression sickness. Consideration of aggravating factors such as physical exertion are also important when evaluating potential cases. This case highlights the necessity for continued research into mitigation strategies for decompression sickness in the aviation environment.

Learning Objectives

1. The audience will learn about considerations when evaluating a potential case of decompression sickness in the context of aviation.
2. The audience will learn about factors that can increase the risk for developing decompression sickness in the aviation environment.

Tuesday, 05/07/2024
Grand Hall GH

10:30 AM

[S-29]: PANEL: AEROSPACE TOXICOLOGY

Chair: Richard Pleus

Co-Chair: David Mattie

PANEL OVERVIEW: Aerospace Toxicology is the multi-disciplinary approach to understanding and managing the effects and impacts of chemical and biological agent exposures while in flight or on the ground, preparing and servicing vehicles for flight to keep humans healthy and safe. Exposures to chemicals associated with all aspects of flight must be understood and managed to ensure everyone associated with aerospace operations is protected. The Aerospace Toxicology Association is a new organization that became an AsMA affiliate in 2023. While having diverse topics, the abstracts in the session all address issues related to toxicology associated with flight or maintenance operations.

[147] MEDICAL CONSEQUENCES AFTER A FUME EVENT: A RETROSPECTIVE MATCHED-PAIR COHORT STUDY IN A MAJOR AIRLINE INVOLVING 15,000 CREWMEMBERS

Michel Klerlein

Air France, Roissy CDG, France

(Original Research)

INTRODUCTION: The so-called "aerotoxic syndrome" following a fume event is still controversial among aviation medicine practitioner. The occupational health department of the main French airline collects data from all the crewmembers exposed to a fume event since the beginning of 2017. **METHODS:** We present a retrospective cohort study involving 14953 crewmembers including 2577 exposed and 12376 matched controls. Our medical recording database uses the ICD-10 classification of diseases. The statistical methods were pairwise comparison of means, matched risk-ratio and Cox proportional hazard models for estimation of risk-ratios, incidence of diseases and prevalence.

RESULTS: From 2017 to 2022, 357 fume events have been notified to the occupational health department, who recorded 2735 crewmember exposed. 2577 have been included as exposed and 12376 as matched controls. Prevalence of diseases that could be related to the fume event based on "possible" or "probable" level and date of occurrence posterior to the fume event was for exposed (controls): NEUROLOGIC 2.57% (2.47%), PSYCHIATRIC 2.80% (3.22%), NEUROVEGETATIVE 1.86% (1.57%), IRRITATIVE 5.08% (4.56%), FUNCTIONAL 2.95% (2.93%). Differences were not significant. Incidences of having any related disease are estimated at 1552 per 100000 person-years for exposed and 1497 per 100000 person-years for controls, with a non-significant hazard ratio of 1.04 [0.86-1.25] in the cox model. A subset of 2577 matched pairs exposed/control allowing specific statistical tests confirmed the lack of difference between exposed and controls: matched-pair risk ratio for any fume event related disease was 1.07 [0.85-1.34] $p=0.54$, and we found exactly the same result with a conditional fixed-effects Poisson regression.

DISCUSSION: Our results clearly show that fume events are globally out of significant clinical consequences for cabin and cockpit crew. This is totally in line with the conclusions of the 2023 Cabin Air Quality Report from the French Agency for Food, Environmental and Occupational Health & Safety (ANSES).

Learning Objectives

1. The audience will learn about the current debate about the reality of the aerotoxic syndrome.
2. The audience will learn about the diseases occurring after exposure to a fume event.
3. The audience will learn about the design of a retrospective cohort study and the interest of epidemiology in the aeromedicine field.

[148] UPDATE: INTERNATIONAL AEROMEDICAL PANDEMIC LESSONS LEARNED

Kris Belland¹, Charles DeJohn², Diego Garcia³, Gary Allen⁴, Stephen Glaudel⁴, Bill Mills²

¹AsMA, Keller, TX, United States; ²AsMA, Oklahoma, OK, United States;

³AsMA, Ormond Beach, FL, United States; ⁴AeroClenz, Bonita Springs, FL, United States

(Education - Tutorial/Review)

BACKGROUND: Worldwide aviation has been greatly and negatively impacted by the COVID-19 pandemic. Right from the outset, organizations, businesses, and individuals within the aviation industries have faced unique and complex challenges. Contingency planning has had to adapt. In this presentation, the author will provide an updated Systematic overview and update to the Aviation Multi-Layered Disease Defense Strategy (AMLDDS) and discuss Emerging risk-mitigations (application of Reason Swiss Cheese Theory to inflight disease transmission/translocation). Strategies will include current and emerging technologies to include the use of airborne Ultraviolet (UV-C)

irradiation. Updates on three AsMA AMHP Blue Journal UV-C paper submissions undergoing peer review and AsMA UV-C Resolution 2023-01, as well as feedback from WHO, ICAO, CAPSCA, AHC, ICASM international conference presentations will be discussed. **OVERVIEW:** The author served as the AsMA representative to the International Civil Aviation Organization (ICAO) and Collaborative Arrangement for the Prevention and Management of Public Health Events in Civil Aviation (CAPSCA) during the last three years of the COVID-19 pandemic and has formed a unique perspective and best business practices. As the pandemic evolved, so did knowledge, attitudes, and expectations. The pandemic has created unique opportunities for learning and scientific technologic advances. Emerging layers of disease risk mitigation protection including the use of UV-C at safe levels and how they can reduce translocation and transmission of disease in flight will be discussed. **DISCUSSION:** After a thorough systematic review of subject publications resulting in three AMHP AsMA Blue Journal submissions, the author will discuss existing and emerging infectious diseases risk mitigation strategies critical to aviation - COVID-19 and beyond, and will provide an overview and update to the AMLDDS and discuss Emerging risk-mitigation (evolutionary application of James Reason, Swiss Cheese Model/Theory which was successfully adapted to international COVID-19 pandemic response by ICAO and CAPSCA. Lessons learned and emerging technologies will continue to reduce inflight disease transmission/translocation of disease and enhance future pandemic responses.

Learning Objectives

1. Attendees will become familiar with updated current programs and future initiatives in supporting aeromedical response to emerging pandemic transmission/translocation and manmade biologic events.
2. Attendees will learn about updated areas of advancement in global preparation for the next pandemic.
3. Attendees will understand updated advantages and potential methods of a multi-layered response to emerging disease transmission and translocation.

[149] INVESTIGATING THE POTENTIAL HEALTH DERMAL AND RESPIRATORY HEALTH EFFECTS ON CREW UNIFORMS

Richard Pleus¹, Gavin Bell², Gretchen Bruce²

¹Intertox/Aerospace Toxicology Association, Seattle, WA, United States;

²Intertox, Seattle, WA, United States

(Original Research)

INTRODUCTION: Aircrew members have raised concerns about skin and respiratory reactions after donning new uniforms, leading to speculation that the uniforms may release chemicals inherent to textile components. This study investigated the potential for these chemicals to cause dermal and respiratory health effects. **METHODS:** We conducted a comprehensive literature review to identify chemicals in aircrew textiles that are potential dermal allergens or respiratory irritants or sensitizers. Additionally, we explored textile certification standards and regulations addressing chemical usage in textiles. Partnering with specialized laboratories, we designed a testing program to collect data aligned with toxicological requirements. Potential health risks were assessed using established risk assessment methodologies. **RESULTS:** Our evaluations revealed the presence of various chemical agents in the textiles. Organic compounds included perfluorooctanoic acid (PFOA) and inorganics included zinc, used in antimicrobial treatments; copper, prevalent in dyes and antifungal agents; and titanium, found in dyes and polymers. We also detected aldehyde emissions including formaldehyde, acetaldehyde, and others. **DISCUSSION:** In a conservative estimate, 1 in 20 individuals already sensitized to zinc might react upon exposure to the maximum detected level of zinc, but risk drops significantly for those not sensitized. Models of aldehyde exposure using emission data from fabrics indicate a probability of respiratory reactions in sensitized and non-sensitized individuals of 1 in 1,000 and 1 in 250,000 respectively, under conservative

exposure scenarios outside of commercial aircraft, and under 1 in 1,000,000 for both groups in commercial aircraft. While data suggest the potential for exposure exceeding toxicity guidelines for some chemicals under conservative scenarios, the overall likelihood of predicted adverse effects is much lower than reported frequency of adverse effects in uniform-wearing groups. Evaluating uniforms for potential chemical exposures before distribution is recommended.

Learning Objectives

1. The audience will understand the types of chemicals found in air crew uniforms.
2. The audience will understand the how to consider and scientifically and medically approach to addressing dermatological and respiratory concerns from uniforms.

[150] OBTAINING KEY MEDICAL INFORMATION REGARDING THE HEALTH IMPACTS OF CHEMICALS IN THE CABIN AIR OF COMMERCIAL AIRCRAFT

Richard Pleus¹, Kelli Hackney², Gretchen Bruce², Cameron Bellamoruso²

¹Intertox, American Toxicology Association, Seattle, WA, United States;

²Intertox, Seattle, WA, United States

(Original Research)

INTRODUCTION: Studies show that small quantities of jet engine oil or hydraulic fluid can seep into commercial aircraft's environmental systems and cabin air. Characteristic odors or fumes may be detected in cabin air by passengers or crew, and some concerns have arisen about the potential health effects of exposure during these fume events. We identified data gaps in the industry approach to collecting air quality and health data post-fume events and propose a comprehensive, multi-tiered health and safety protocol for these events. **METHODS:** We extensively reviewed and analyzed literature and guidance from authoritative entities as well as reports and medical data from several incidents to identify where data gaps exist in current industry procedures. We used James Reason's "Swiss cheese model" as a framework to bridge data gaps. **RESULTS:** Data gaps existed in education and training, procedures, communication and reporting, data collection and analysis, and medical information. We focused primarily on identifying actions to bridge data gaps in data and medical information collection, including: 1. Enhancing the aircrew questionnaire to standardize and obtain air quality and health data post-fume event, focusing on toxicologically pertinent details such as odor characteristics, event duration, and symptoms. 2. Providing relevant exposure information to medical providers responding to fume events and proposing a program to guide them in adopting medically grounded diagnostic methods, aiming to increase chances of apt medical care. **DISCUSSION:** Building upon existing carrier measures, we developed a comprehensive multi-tiered health and safety protocol to respond to cabin air fume events, to support enhanced, dependable data collection, and to aid the medical community in addressing aircrew exposures.

Learning Objectives

1. The audience will understand the medical concerns of the need for better quality medical data regarding fume events.
2. The audience will understand the types of medical information that is currently obtained and what information would be scientifically and medically useful.

Tuesday, 05/07/2024
Grand Hall I

10:30 AM

[S-30]: SLIDES: SPACE- THE BIG PICTURE

Chair: Moriah Thompson

Co-Chair: Jennifer Fogarty

[151] A SYSTEMATIC REVIEW OF LITERATURE FOR DESIGN OF LUNAR HEALTH MAINTENANCE FACILITIES (HMF) IN LUNAR MISSIONS

Souktik Bhattacharjee, Amit Srivastava

The University of Adelaide, Adelaide, Australia

WITHDRAWN

[152] DETERMINING PHARMACUETICAL STABILITY AFTER LONG-DURATION EXPOSURE TO SPACEFLIGHT ABOARD THE INTERNATIONAL SPACE STATION: PHASE 1 OF THE DRIBBLE STUDY

Corinne Rezendes¹, Dennis Lovett², John Reichard³, Craig Nowadly²

¹Brooke Army Medical Center, San Antonio, TX, United States; ²59th Medical Wing, San Antonio, TX, United States; ³NASA JSC, Houston, TX, United States

(Original Research)

INTRODUCTION: Pharmaceuticals on the International Space Station (ISS) are exposed to high ambient carbon dioxide levels, solar and galactic cosmic radiation, and microgravity. Previous research raised concerns that the unique environment of spaceflight may lead to degradation of active pharmaceutical ingredients. The mechanisms by which spaceflight facilitates loss of API potency remain poorly characterized. The "Dribble" study was performed to fill that knowledge gap. **METHODS:** FDA-approved pharmaceuticals were packaged by the Johnson Space Center (JSC) pharmacy into spaceflight (experimental) and lot-matched ground controls. Experimental pharmaceuticals were launched to the ISS aboard SpaceX CRS-15, CRS-16, CRS-17, CRS-18, CRS-20, and Cygnus NG-11. Ground controls remained in stability chambers at JSC. Space-exposed pharmaceuticals returned to Earth and were placed into stability chambers. After an unexpected delay caused by the COVID-19 pandemic, the pharmaceuticals were transferred to the US Air Force for analysis. Solid and liquid pharmaceuticals were appropriately prepared and sampled ten times. Each sample was subsequently tested utilizing ultra-high-performance liquid chromatography and tandem mass spectrometry. Experimental and controlled medications were compared against commercial standards for each medication. Phase 1 analysis of Dribble includes: caffeine (tablet), diazepam (vial), diphenhydramine (vial and capsule), epinephrine (vial), ketamine (vial), lidocaine (vial), naloxone (vial), and promethazine (tablet and vial). **RESULTS:** Experimental medications were stored on the ISS 132 – 573 days, varying by medication and mission. All pharmaceuticals were expired at the time of analysis. During a preliminary analysis, Naloxone 1 mg/mL vials showed no significant degradation in flown or control samples across three missions (potency ranging 97.6 ± 2.3% to 102.1 ± 2.9% of commercial standard). By contrast, there were epinephrine samples flown on SpaceX CRS-15 and SpaceX CRS-17, showed an 8.3-10.3% lower potency relative to ground controls. **DISCUSSION:** The "Dribble" pharmaceuticals showed varying stability and degradation patterns. Although all medications were expired at the time of analysis, the time period of analysis is relevant to exploration missions. This study will allow for informed development of exploration pharmaceutical programs. Immediate follow-up of Phase 2 medications is planned.

Learning Objectives

1. Understand the stability and degradation patterns of select medications across varying exposures to microgravity.
2. Understand the factors that influence stability and degradation of select medications across varying exposures to microgravity.
3. Understand the relevance of pharmaceutical stability to exploration spaceflight.

[153] ENABLING DEEP SPACE MISSIONS WITH AN EXPLORATION MEDICAL SYSTEM

Sara Khan, Sylwia Kaduk

KBR - European Space Agency, Cologne, Germany

WITHDRAWN

[154] SPACE MEDICINE AND HUMAN FACTORS RESEARCH GAPS IN SUPPORT OF HUMAN COMMERCIAL SPACE FLIGHTS

Melchor Antunano

FAA CAMI, Oklahoma City, OK, United States

(Education - Program/Process Review)

Space flight exposes individuals to an operational environment that is far more hazardous than what is experienced by passengers who fly onboard current airline transports. With suborbital and orbital flights, pre-existing medical conditions can be aggravated or exacerbated by exposure to environmental and operational stressors such as acceleration, microgravity, and solar/cosmic radiation, among others. Most of the space medicine knowledge and experience to date has been obtained from career astronauts between the ages of 35 and 50 years old. Most of the biomedical data (medical, physiological, psychological) collected to date are based on the effects of space flight (short and long) on generally healthy career space crews. Because of medical privacy laws and individual space career considerations, individual biomedical data from career space crews is not readily available for scientific study. There is a limited amount of medical information on pathologies occurred among career astronauts during short-duration and long-duration space flights. Limited biomedical information has also been collected and analyzed from commercial spaceflight participants in suborbital and short-duration (up to 2 weeks) orbital flight. Furthermore, available biomedical information from spaceflight participants who have moderate-to-severe pathology is also very limited (quantitatively and qualitatively). Such an insufficient level of overall medical knowledge and experience represents a challenge to those space medicine practitioners who are responsible for the medical assessment of prospective commercial spaceflight participants who have a wide range of health and fitness levels. Therefore, more space medicine research is needed to address the medical safety of spaceflight participants. This presentation will discuss: 1) Examples of relevant space medicine and human factors research conducted through the FAA CST COE, 2) The space medicine research gaps identified in the final report of the CSF/MITRE Workshop to Create a Human Research Program for Spaceflight Participants in the Commercialization of Space, and 3) Ongoing FAA internal discussions about research priorities in aerospace medicine and human factors in support of human commercial spaceflight operations.

Learning Objectives

1. The audience will learn about high priority research needs in space medicine and human factors in support of human commercial space flights.
2. The audience will learn about completed research areas in space medicine and human factors conducted through the FAA Commercial Space Transportation Center of Excellence.

[155] WILLIS ISLAND RESEARCH STATION- A RETROSPECTIVE SPACEFLIGHT TELEHEALTH ANALOGUE

Meg O'Connell

Royal Flying Doctors Service- Queensland, Cairns, Australia

(Original Research)

INTRODUCTION: Willis Island is a remote isolated weather station located approximately 450km East of the coast of North Queensland, Australia. Established in 1921, Four live-in staff deploy for six-month

rotations in isolated, resource limited, extremely remote circumstances. Like the International Space Station, research staff perform scientific experiments, weather forecasting and maintenance activities. Exploration medical support is provided by Royal Flying Doctors Service Queensland Service (RFDS) Telehealth Medical Officer and supported by an on island RFDS Medical Chest. Like ISS astronauts, researchers undergo first aid training, emergency management planning and communications training prior to deployment. Like spaceflight, the island presents many medical risks, including radiation injuries from the sun, skin and musculoskeletal injuries, decompression illness, and the psychological difficulties of working in small, isolated teams for long periods of time. This research uses retrospective analysis to determine if the medical issues faced by small group extreme deployments is comparable to those experienced during spaceflight. **METHODS:** This site was analysed at length to determine if it was a naturally occurring retrospective spaceflight analogue. Hazards, risks, medical evacuation, pre-deployment training, and onsite medical facilities were compared and contrasted between the ISS, Space Shuttle Missions and Willis Island operations. A literature review of the medical incidents experienced by ISS Astronauts over the same time period was completed. **RESULTS:** A total of 81 telehealth phone calls were made from Willis Island during the study period. This is a mean phone calls of 5.4 per year, but likely reflects the young and health population self-selecting to deploy. The most common injuries were musculoskeletal and skin injuries, followed by ear infections. Over the last 16-year period, only one phone call was related to a mental health issue. **DISCUSSION:** Remote Island scientific bases represent a goldmine of useful data that can inform expedition and wilderness medicine, along with aerospace medicine. This research paper has demonstrated that retrospective analysis of remote places can be used to better understand human spaceflight healthcare and its limitations for small and isolated deployments.

Learning Objectives

1. Participants will learn the methodology of how to evaluate remote places to understand if they are an analogue for spaceflight telehealth.
2. Participants will get a better understanding of the RFDS remote telehealth service, accompanied by the RFDS medical chest, a locked box of 50 medications including emergency drugs. There are 2500 of these throughout Australia.

[156] DEVELOPMENT OF TAILORED TRAUMA GUIDELINES FOR SPACE EXPLORATION UTILIZING KNOWLEDGE FROM MAJOR TERTIARY TRAUMA CENTERS

Lisa Brown¹, Jeremy Hsu², David Read¹, Kate Martin¹, Rose Shakerian¹, Anthony Phillips³, Benjamin Thomson¹

¹The Royal Melbourne Hospital, Melbourne, Australia; ²Westmead Hospital, Sydney, Australia; ³The University of Auckland, Auckland, New Zealand

(Original Research)

INTRODUCTION: Guidelines for the management of major trauma are used terrestrially to guide and subsequently evaluate complex trauma situations. Prior research exists on the altered human physiology encountered in microgravity and how this would influence a trauma patient in the environment of the Moon, Mars or within a space vehicle. NASA's Integrated Medical Model confirms that trauma situations are a significant component of the medical risks in space exploration.

METHODS: The aim of this study was to develop trauma guidelines for space exploration - integrating current knowledge of human physiology, specifically related to trauma in microgravity, with current trauma guidelines from major Australian surgical trauma services. A review of the major medical databases (Pubmed, Medline, Ovid, Google Scholar) was undertaken using keywords of ("TRAUMA" OR "ACCIDENT") and ("MICROGRAVITY" OR "SPACE" OR "MOON" OR "MARS"). Expert Trauma Surgeon review was then performed of the results with application of the currently used Hospital (The Royal Melbourne Hospital, Melbourne

and Westmead Hospital, Sydney) trauma guidelines to space exploration. **RESULTS:** Understanding of human physiology in microgravity is critical in the management of trauma with long duration missions to the Moon and Mars. A trauma guideline specifically for microgravity was developed based on current major trauma centres guidelines. Specific considerations within the guideline included: the use of diagnostic peritoneal lavage in the absence of cross-sectional imaging; Focused Assessment with Sonography for Trauma (FAST) scan training for Astronauts; considerations for chest drain use in the altered pressure environment and specifically re-entry; and development of stabilisation of fractures through minimal weight or 3D printed devices. **DISCUSSION:** Current trauma guidelines can be modified to develop tailored guidelines for space exploration. Trauma guidelines from major trauma centres were reviewed and compared to known physiological responses in microgravity and an applicable guideline developed.

Learning Objectives

1. The audience will learn about physiology in microgravity as it relates specifically to trauma.
2. The audience will learn of a trauma guideline for space exploration developed in conjunction with currently used major center trauma guidelines.

Tuesday, 05/07/2024
Grand Suites 2 & 3

10:30 AM

[S-31]: POSTERS: TRAVEL TRANSPORT AND SAFETY

Chair: Erin Smith

Co-Chair: Andrew Lam

[157] COMPARISON OF EMERGENCY AIR MEDICAL TRANSPORT UTILIZATION IN THE TAIWAN OFFSHORE ISLANDS

Hsin-Pei Liu¹, Hsin Chu², Hsin-Hui Chen³, Chung-Yu Lai⁴, Hao Su⁵, Ko-Chiang Hsu³

¹Taoyuan Armed Forces General Hospital, Taoyuan City, Taiwan (Greater China); ²Civil Aviation Medical Center, Taipei City, Taiwan (Greater China); ³Tri-Service General Hospital, National Defense Medical Center, Taipei City, Taiwan (Greater China); ⁴National Defense Medical Center, Taipei City, Taiwan (Greater China); ⁵The 4th Tactical Fighter Wing of ROCAF, Chiayi City, Taiwan (Greater China)

(Original Research)

INTRODUCTION: With over a hundred offshore islands separated by sea from the Taiwan mainland, the necessity for advanced medical care often leads patients to rely on Emergency Air Medical Transport (EAMT) to reach healthcare facilities on the mainland. The Ministry of Health and Welfare (MOHW) is committed to improving the healthcare infrastructure in these remote island areas. Therefore, the primary objective of this study is to analyze and present the evolving patterns of EAMT utilization across the various islands in the region. **METHODS:** This was a cross-sectional study to analyze the National Health Insurance Research Database (NHIRD) and the EAMT Data (EAMTD) provided by the MOHW. Information regarding emergency visits was extracted from the NHIRD files specifically labeled "Ambulatory care expenditures by visits". The number of patients moved by air was collected from the EAMTD accessible through the MOHW's official website. The rates and trends of the EAMT during the period spanning from 2016 to 2018 will be presented according to the distinct geographical regions, namely Penghu, Kinmen, and Matsu. **RESULTS:** A total of 521 patients were transported by the aircraft with varying numbers distributed across distinct regions: Penghu accounted for 213 patients, Kinmen for 199 patients, and Matsu for 109

patients. The rates of the EAMT for emergency visits showed a consistent upward trend across all three regions. Penghu had the lowest rate, at 19.1 visits per 10,000, while Kinmen recorded rates of 25.5 visits per 10,000, respectively. Notably, Matsu had the higher rate, with 51.3 movements per 10,000 visits. **DISCUSSION:** In recent years, this work was the first study to illustrate the EAMT rate by the integration of the released information in Taiwan. Our findings shed light on the actual EAMT rates in various regions. These discrepancies in rates may be attributed to variations in resources and capabilities within the local medical facilities. Authorities can use these observed rates as benchmarks so as to evaluate the effectiveness of their policy implementations.

Learning Objectives

1. To obtain the proportion of EAMT utilization across the various islands.
2. To use the observed rates as benchmarks to evaluate the effectiveness of policy implementations.

[158] PREVALENCE OF DEGENERATIVE FINDINGS IN LUMBAR SPINE AMONG MILITARY ROTATING WING PILOTS OF AN AIR BASE LOCATED IN THE STATE OF MEXICO.

Vicente Lozada-Balderrama¹, Liliana Reyes-Castañeda², Jesús José Arreola-Bastidas³, Nadia María Espinosa-Largo⁴, Alejandro Vieyra-González¹

¹Instituto Politécnico Nacional, Mexico City, Mexico; ²Hospital Militar Regional Santa Lucía, Santa Lucía, Mexico; ³Hospital Militar de Zona de Apatzingán, Apatzingán, Mexico; ⁴Hospital Central Militar, Mexico City, Mexico

(Original Research)

INTRODUCTION: Mechanic vibrations produced during the flight on rotary wing aircraft have been widely associated with the presence of neck and back pain, and in some studies, with cases of degenerative disk disease. This study aims to calculate the prevalence of degenerative disk disease in military rotary wing pilots of an air base located in the State of Mexico. **METHODS:** Descriptive, analytical, cross-sectional study with convenience sampling of 35 pilots between 20 and 40 years old, apparently healthy, BMI lower than 28 points, total flight hours (FH) resulted between 480 and 3370. Between January and April 2017, after signing an informed consent form every pilot went under a nuclear magnetic resonance interpreted later by an experienced radiologist based on Pfirrmann classification. For statistical analysis the sample was divided in three groups, Group 1: 480-1000 flight hours; Group 2: 1000-2500 flight hours; Group 3: >2,500 flight hours. Descriptive and inferential statistic tests were performed. Method was previously approved by National Bioethics Commission.

RESULTS: Age mean was 32.86 ± 4.78 years old, weight mean 79.37 ± 7.19 Kg, BMI mean 26.01 ± 1.51 points, helicopter flight hours mean 1 065 ± 893.39. Prevalence of degenerative disk damage was 91.42% (n=32). Pfirrmann grade 1 changes were found in 2.86% (n=1, with 1,043 FH), grade II was found in 45.71% (n=16, X=1,680.38 FH), grade III in 25.71% (n=9, X=603.78 FH) and grade IV in 20% (n=7, X=1,943.86 FH). Most frequent affected region was L1-S1 in 48.57% (n=17). Statically significant difference was found in Pfirrmann stage between group II and IV. No statically significant association between groups and Pfirrmann staging was found. **DISCUSSION:** Prevalence of discal degenerative findings in military pilots was higher than the prevalence in general population. Pfirrmann grade II was the most frequently found in rotary wing pilots.

Learning Objectives

1. The audience will be able to perceive the difference between the prevalence of findings of disc degeneration in general population and in military rotary wing pilots.
2. The participants will know about the effects of flying rotary wing aircraft, a reliable method to assess disk damage and its associations with job characteristics.

[159] OPIOID OVERDOSE INCIDENCE ON US COMMERCIAL FLIGHTS

Ritwik Keshav, Paulo Alves, Justin Devlin, Neil Nerwich
MedAire, Phoenix, AZ, United States

(Original Research)

INTRODUCTION: Opioid overdose is a major cause of death and hospitalizations in the US. The overall incidence of non-fatal opioid overdose emergency department visits in the US is 133.9 per 100,000 people. It is reasonable to expect opioid overdose to affect passengers in-flight. The objective of this study is to estimate the incidence of opioid overdoses on commercial airline flights. **METHODS:** Data from 2022 were extracted from an internal database of in-flight medical events collected by a major ground-based medical support provider among major US airlines. Potential opioid overdoses were flagged using multiple criteria with different degrees of certainty into three scenarios: Conservative, Medium, and Liberal. The conservative scenario only included cases of clinical suspicion and naloxone administration. Medium included the "conservative" cases plus cases identified by a ChatGPT-4 analysis of events categorized by the doctors as "Altered Mental Status". The artificial intelligence platform was trained to identify cases of potential overdose using standard diagnostic criteria. The liberal scenario included the "medium" cases plus cases of non-shockable cardiac arrests in adults aged 20-55. Published passenger traffic for 2022 was obtained for the airlines involved in the same period of the study. Incidence was calculated as events per passenger. **RESULTS:** 14,788 in-flight medical events affecting US airlines in 2022 were available for analysis. Seven airlines were represented, for a total of 400,263,000 passengers. Applying the predefined criteria, incidence was calculated as:

- Conservative Scenario: 12 cases. Incidence: 1 per 33.4 million passengers
- Medium Scenario: 44 cases. Incidence: 1 per 9.1 million passengers
- Liberal Scenario: 54 cases. Incidence: 1 per 7.1 million passengers

DISCUSSION: The findings suggest that the incidence of opioid overdoses on commercial airline flights is relatively low, below the incidence of other serious medical events even when using the most liberal inclusion criteria. The discrepancy between this and national incidence of opioid overdose may be due to the limited duration of flights or specific demographics of individuals that fly. There are important limitations in this study given the retrospective nature of data analysis and the absence of confirmatory evidence of opioid utilization in the cases identified.

Learning Objectives

1. The audience will learn that the incidence of opioid overdose for in-flight medical events is relatively low, even if we use the most inclusive criteria for the estimation.
2. The audience will learn how we approached a way to estimate the incidence of opioid overdose for in-flight passengers by using a risk-stratified approach.

[160] WHERE AND HOW WELL DO CABIN CREW SLEEP DURING LONG-HAUL FLIGHTS?

Lucia Arsintescu¹, Cassie J Hilditch¹, Sean Pradhan², Kevin B Gregory³, Erin E Flynn-Evans³

¹San Jose State University, San Jose, CA, United States; ²Menlo College, Atherton, CA, United States; ³NASA Ames Research Center, Moffett Field, CA, United States

(Original Research)

INTRODUCTION: Sleep loss and circadian disruption pose a significant risk in aviation. Many studies have shown that in-flight rest locations influence alertness and performance among pilots, but few studies have evaluated cabin crew. The aim of this research was to assess sleep outcomes among cabin crewmembers sleeping in a bunk during both outbound and inbound compared to alternating sleep in a bunk or

a jump seat during one long-haul route. **METHODS:** Twenty-nine (5 male) cabin crewmembers ($M_{age} = 30.61$, $SD = 2.91$) flew the same long-haul route (outbound and inbound) with a flight duration of 10:41 ($\pm 0:14$) hours. Participants were randomly assigned to fly on an aircraft with a bunk in both directions or to fly an aircraft with a bunk in one direction and with a high comfort jump seat (HCJS) in the other direction for their sleep opportunity. They wore an Actiwatch throughout the entire study and completed a sleep diary at bedtime and upon waking for each sleep opportunity. Seventy-seven percent of the flights had a bunk and 23% had a HCJS. A series of mixed-effects models were performed to assess the differences in several sleep parameters when crewmembers slept in the bunk during both directions of the flight (bunk-only) compared to sleep obtained in the HCJS during one direction and bunk in the other (bunk+HCJS). **RESULTS:** Fifty-seven flights were included in the analyses. There were significant differences between sleep time ($b = 22.56$, $SE = 9.07$, $p = .02$, Hedges' $g = -0.65$) and sleep efficiency ($b = 16.75$, $SE = 4.49$, $p = .001$, Hedges' $g = -1.07$) obtained in bunk-only vs. bunk+HCJS. Crewmembers obtained more sleep and had better sleep efficiency when they slept only in the bunk compared to bunk+HCJS. **DISCUSSION:** Our results showed that cabin crewmembers slept longer and had better sleep efficiency when they used the bunk. Further research is needed to understand how subjective sleepiness and subsequent performance are influenced by sleep opportunity in a bunk-only compared to bunk+HCJS. **Learning Objectives**

1. Understand where and how well cabin crew sleep during long-haul flights.
2. Provide awareness of the need to study cabin crew fatigue and performance during long-haul flights.

[161] HYPOXIA INCREASES NF- κ B ACTIVATION AND CYTOKINE EXPRESSION BUT DECREASES EXPRESSION OF IRF5/7, JUN AND INTERFERONS IN SMALL AIRWAY EPITHELIAL CELLS

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²Xin Tai General Hospital, New Taipei City, Taiwan (Greater China)

WITHDRAWN

[162] HYPOXIA-REOXYGENATION INDUCED DYSREGULATED MIRNA EXPRESSION ASSOCIATED WITH LUNG INJURY AND IMMUNE DYSFUNCTION IN HUMAN SMALL AIRWAY EPITHELIAL CELLS

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¹National Defense Medical Center, Taipei, Taiwan (Greater China);

²Taipei Tzu Chi Hospital, New Taipei City, Taiwan (Greater China)

(Original Research)

INTRODUCTION: Hypoxia-reoxygenation (H/R) has been shown to occur during transition from the hypobaric hypoxic cabin environment in air traveling to normobaric normoxia during landing, and it mimics the ischemia-reperfusion situation encountered in vivo during organ transplantation. Hence we are interested in studying whether exposure to H/R may influence the expression of microRNAs that regulate airway inflammation, immunity and injury in human small airway epithelial cells (SAECs). **METHODS:** The normal and COPD-diseased SAECs (respectively N-SAECs and D-SAECs) were purchased from Lonza Biotechnology Company and respectively cultured under normoxia (21% O₂) or under 24/24-hour cycles of H/R (i.e., 1% O₂ and 21% O₂ alternately) for 6 days in total, followed by extraction of total RNAs for small RNA sequencing. **RESULTS:** We found that most of the microRNAs (miRNAs) showing dysregulated expression levels in the SAECs exposed to H/R are either tumor suppressors or oncogenes and reveal opposite fold changes in N-SAECs and D-SAECs. Among the miRNAs showing expression changes in the same direction in both types of SAECs under H/R, upregulated tumor

suppressor miR-147b-3p and downregulated oncogene miR-483-3p both contribute to elevated airway inflammation by increasing IL-6 and TNF- α expression and promoting IGF1-induced NK cell activity. In addition, downregulated oncogene miR-483-3p, together with the upregulated oncogene miR-1290 and downregulated tumor suppressor let-7c-3p in both N-SAECs and D-SAECs cultured under H/R, are associated with increased pulmonary fibrosis. On the other hand, downregulated oncogene miR-27a-3p in D-SAECs and upregulated miR-193b-5p in both N-SAECs and D-SAECs under H/R are associated with GSK3 β - and TNF-inhibited expression of the tight junction proteins Claudin-5 and Occludin, and may contribute to the LPS- and TNF-induced acute respiratory distress syndrome (ARDS) and lung injury. Interestingly, both of the NRF2-regulated miRNAs, miR-365a-5p and miR-365b-5p, were upregulated in N-SAECs whereas downregulated in D-SAECs, while miR-365b-5p has been reported to target the 3' UTR of the SARS-CoV-2 RNA. **DISCUSSION:** Our study reports for the first time that hypoxia-reoxygenation induces dysregulated miRNA expression associated with increased airway inflammation, pulmonary fibrosis and ARDS lung injury in both the healthy and COPD-diseased SAECs.

Learning Objectives

1. The audience will gain knowledge about how hypoxia-reoxygenation will change the expression level and different functions of various small RNAs in human small airway epithelium.
2. The audience will understand what are the common and differential changes of small RNA functions in the healthy versus COPD-diseased airways exposed to hypoxia-reoxygenation, and how the dysregulation of these microRNA levels may affect the etiology of the airway epithelium.

[163] SECONDARY AERO-RESCUE, "THE NEW CONCEPT OF MEDICAL CARE IN THE TRANSFER OF CRITICAL PATIENTS BY AIR"

Wagner Samaniego¹, Vicente Ciancio², Marcos Saldivia³

¹Hospital Regional De Coyhaique, Coyhaique, Chile; ²Universidad De La Plata, La Plata, Argentina; ³Samu, Coyhaique, Chile

WITHDRAWN

[164] TITLE: SUITABILITY OF ARMY AMBULANCE MEDICAL EQUIPMENT SETS AND CONSUMABLE SUPPLIES FOR ARCTIC OPERATIONS

Sarah Snyder, Laura Kroening

U.S. Army Aeromedical Research Laboratory, Fort Novosel, AL, United States

(Original Research)

INTRODUCTION: U.S. Army operational forces are not currently "Arctic-capable." The performance of essential military MES items used in en route care (ERC) patient transport has not been studied or tested in the arctic environment. **METHODS:** Retrospective data was consolidated from patient movement items (PMI) and reviewed from the U.S. Aeromedical Research Laboratory's Enroute Care Group Testing & Evaluation team to determine the temperature operating range and average battery life of the U.S. Army's most current air ambulance electronic medical equipment set (MES). The project lead performed a site visit July 2023 to Fort Wainwright, AK and Fort Greely, AK to look at medical evacuation (MEDEVAC) capability gaps identified from operational active-duty Critical Care Flight Paramedics (CCFPs) serving in Charlie, 1-52 General Support Aviation Battalion, 16th Combat Aviation Brigade, at an active-duty cold weather location outside the continental U.S. **RESULTS:** A site visit to Fort Wainwright, AK revealed reports from CCFPs serving in Alaska are performing MEDEVAC operations in temperatures as low as -37 to 40 degrees Celsius (-34.6 to -40 degrees Fahrenheit). Generally, the electronic MES can

operate under the current Joint En route Care Equipment Test Standard, Revision 1 (JECETS, Rev. 1) standards, but the affiliated battery systems will most likely deplete in Arctic operations before the electronic MES item(s) malfunction(s) or become inoperable. **DISCUSSION:** The current JECETS, Rev. 1, which is used for airworthiness release certification and aeromedical certification to add PMI to the standing Aeromedical Certification Memorandum, does not meet the cold weather operational requirements for tactical ERC under arctic weather conditions.

Learning Objectives

1. To determine if the performance of essential electronic military MES items used in ERC patient transport are suitable for Army rotary-wing MEDEVAC in arctic environments.
2. This abstract seeks to identify if the current JECETS, Rev. 1 for Climatic – Low Temperature testing of electronic MES item(s) used in ERC are suitable for MEDEVAC operations in subzero, arctic operating environments.

[165] MEDICAL SELF-DISCLOSURE RATES AMONG NAVAL AVIATORS

Michael Weipert, Jacob Westerberg, Jonathan Elliot

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

(Original Research)

INTRODUCTION: Aviators can be hesitant to disclose medical information to their flight surgeons for fear of negative repercussions. However, failing to disclose this information can have negative health and financial consequences, both short- and long-term. Without full medical information, an aviator's medical record cannot be updated, making it difficult to identify and treat illness or disease in the acute phase. Furthermore, VA disability claims may not be granted in the future without proper documentation in a service member's Service Treatment Record (STR). Well before that point, untreated medical conditions may also represent an operational flight safety concern. **METHODS:** To determine what percentage of Naval Aviators are not disclosing health concerns, and to further identify what types of medical issues aviators are reticent to disclose, a cross-sectional epidemiological study using an original survey was conducted among designated aviators at Naval Aviation Safety Command. **RESULTS:** The study found that 57% of Naval Aviators have failed or are failing to disclose medical concerns to their flight surgeons. The study also revealed that only small percentages of aviators were willing to discuss concerns in particular medical categories: Psychiatry (17%), Neurology (23%), Medication/Supplements (27%), Internal Medicine (34%), and Pulmonary (36%). The Naval Aviators were also asked to comment on how many of their fellow pilots regularly did not disclose medical concerns; over half of those surveyed believe that a majority of their peers are flying despite experiencing undisclosed medical concerns. **DISCUSSION:** The survey revealed that a large percentage of Naval Aviators are unwilling to take advantage of the medical system that the Navy currently provides. The problem of aviators not confiding in their flight surgeons is not new, but this study showed how widespread the problem remains. Aviators who are unwilling to seek medical care for themselves present a potential safety risk, in addition to possibly denying themselves future VA health benefits. The information collected here can help influence Navy policy to improve aviators' experience of aerospace medicine and serve as a call for further research into how to effect meaningful changes.

Learning Objectives

1. Identify the prevalence of Naval aviators not disclosing medical concerns to their flight surgeons and determining how widespread this problem is in the Naval aviation community.
2. Identifying which medical conditions Naval aviators are more likely to discuss with their flight surgeons and what conditions Naval aviators are most likely to not disclose.

[166] DEVELOPMENT OF POINT-OF-CARE TESTING TECHNOLOGY FOR 20 TYPES OF CHEMICALS THAT COULD CAUSE INFLIGHT INCAPACITATION

Yuan Luo, Zhusong Mei, Longmei Fang, Qiao Ye, Bingqian Guo, Dongyun Feng, Lu Wang, Guangyun Wang
Air Force Medical Center, Air Force Medical University, PLA, P.R. China, Beijing, China (Mainland)

WITHDRAWN

[167] PILOT PREFERENCES FOR SLEEP DATA COLLECTION AND DATA SHARING USING CONSUMER SLEEP TECHNOLOGIES (CSTS)

Jaime Devine, Jake Choynowski, Steven Hursh
Institutes for Behavior Resources, Baltimore, MD, United States

(Original Research)

INTRODUCTION: Regulatory bodies that govern aviation, such as the Federal Aviation Administration (FAA), require organizations to collect objective sleep data to ensure that crew members are obtaining sufficient sleep. Consumer sleep technologies (CSTs) are increasingly popular and may become a viable tool for collecting sleep data in aviation. However, pilot preferences and willingness to share data from CSTs has not been investigated beyond anecdotal reports. The current study assesses pilot opinions about the use of CSTs for work purposes and their preferences on data sharing with the goal of improving participant compliance to data collection. **METHODS:** Pilots were asked to provide information about their duty length, CST use, and to give their opinions about the use of CSTs during operations and their willingness to share data under a variety of circumstances. CST users reported brand preferences; non-users reported reasons for non-use. All respondents indicated what type of device they thought would be best for aviation and rated their likelihood to share data with their organization under a series of hypothetical situations. **RESULTS:** One hundred and eight pilots from short haul (n=56), medium haul (n=33), long haul/ultra long range (n=16), or on-call (n=2) responded between Jan-July 2023. Smart watch CSTs were preferred by 37% of pilots. Apple was the preferred brand by 26% of CST-users. Twenty percent of non-users cited "no need" as their reason; only 9% of non-users mentioned privacy concerns. Pilots were most likely to share data with their organization if they were given a sleep tracker by their organization. **CONCLUSIONS:** Pilots seem most willing to provide sleep data from a CST if the organization provides the device. There was not overwhelming brand loyalty among current CST users; reasons for not using a CST were ambivalent rather than distrustful. Taken together, these findings suggest that organizations could increase compliance to data collection by supplying pilots with company-purchased CSTs for data collection or continuing to use research actigraphs.

Learning Objectives

1. This survey establishes pilots' willingness to share data using consumer sleep trackers.
2. This survey explores pilots' reasons for using or not using a consumer sleep tracker.

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

Shannon McGovern, Ardyn Olszko, Alicia Abraczinskas, Christine Beltran, Kimberly Vasquez, Valeta Chancey
U.S. Army Aeromedical Research Lab, Fort Novosel, AL, United States

(Original Research)

INTRODUCTION: The Biodynamics Data Resource (BDR) at the U.S. Army 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 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 extrapolate the non-injurious human responses 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 the largest bin size. Data were matched based on exact categorical and numeric parameters within a tolerance range.

RESULTS: Fifteen parameters had high-priority classification: categorical (6) and numeric (9). The data spread for most 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. While future work could apply these methods solely over the HRV range and decrease bin sizes to optimize groups with matched parameters, real-world data and subject variability may not be suitable for such statistical binning to determine matched pairs.

Learning Objectives

1. Learn a methodology for matching datasets across multiple subject types for a variety of matching parameters, where parameters included are both numeric and categorical.
2. Learn that when assessing exposures across multiple subject types and intensities, parameters chosen to match must be limited by relevance to the research question to make comparisons.

[169] A BIOFIDELIC TESTING METHODOLOGY FOR AIRCREW HELMETS

Alasdair Mackay¹, Matthew Lewis¹, Mazdak Ghajari²

¹Royal Air Force Centre of Aerospace Medicine, Henlow, United Kingdom;

²Imperial College, London, United Kingdom

WITHDRAWN

Tuesday, 05/07/2024

Grand Ballroom CD South, EF

2:00 PM

[S-32]: PANEL: HIGHLIGHTS AND LESSONS LEARNED FROM THE FIRST MISSIONS AT A COMMERCIAL SPACE COMPANY

Chair: Michael Harrison

PANEL OVERVIEW: The first spaceflight missions at any organization provide a number of opportunities to learn lessons and refine processes. This panel summarizes the first three missions flown by a commercial space company while highlighting the differences associated with meeting the needs and satisfying the priorities of the different types of commercial spaceflight

customer who may fly. This evolution occurred in less than 24 months and is likely to continue as planning and training occurs for the fourth and subsequent future missions. To date, the missions have included a individuals of different ages, backgrounds, cultures, and experience in extreme environments. These lessons are crucial in establishing processes and practices by which to make commercial spaceflight safely accessible to all.

[170] PRIVATE ASTRONAUT MISSIONS TO THE ISS: LESSONS LEARNED IN OPERATIONAL AEROSPACE MEDICINE

Ted Duchesne¹, Michelle Hong², Melinda Hailey¹, William Powers², John Marshall², Alexander Rubin¹, Lindsey Hieb¹, Mayur Bhakta¹, Michael Harrison²

¹Axiom Space Inc, Houston, TX, United States; ²Axiom Space Inc & Hercules Medical Group, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: As part of its strategy to support the growth of a Low Earth Orbit (LEO) economy, National Aeronautics and Space Administration (NASA) introduced the opportunity for commercial providers to utilize the International Space Station (ISS) as a destination for Private Astronaut Missions (PAM). Since that announcement in 2019, Axiom Space has medically certified, trained, and successfully completed two PAM missions to the ISS comprised of Axiom employee astronauts, private individuals, and non-US government astronauts. **OVERVIEW:** A successful private astronaut mission required the medical team to work within the resources and legal framework of a private company while interfacing with a wide variety of people including medical and non-medical personnel in various government agencies and within other private companies, external project managers, and personal executive assistants to name a few. Moreover, each mission was comprised of a unique complement of astronauts with varying backgrounds. In 2022, Ax-1 became the first all-private astronaut mission to the International Space Station. This was followed by Ax-2 in 2023 which included privately flown non-US government astronauts. Axiom Space is currently preparing for Ax-3 which includes astronauts representing five countries from three different government agencies. **DISCUSSION:** The Axiom private astronaut missions represent a number of operational firsts including: 1. large scale medical selection efforts with a foreign government and 2. collaboration with multiple government agencies to provide appropriate risk assessment and medical certification for both private and foreign government-sponsored astronauts. In addition to assisting with selection, medical certification, and maintaining crew health and wellness, Axiom's medical team helped develop a flight controller certification plan for their console positions, managed mission related food, developed medical quarantine standards, provided launch and landing support, assisted with crew family support, and were integrally involved in contingency situation planning.

Learning Objectives

1. The audience will learn about the wide range of individuals who are potential commercial space crewmembers and the unique considerations associated with providing medical support for their spaceflight.
2. The audience will be able to identify common processes associated with providing medical support for a commercial space mission at one company.
3. The audience will understand the challenges associated with supporting a commercial space mission in the current legislative context.

[171] OPERATIONAL CHALLENGES OF FACILITATING MEDICAL CARE FOR THE FIRST ALL PRIVATE CREW TO THE ISS

Alexander Rubin¹, Michelle Hong²

¹Axiom Space, Houston, TX, United States; ²Axiom Space/Hercules Medical Group, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: Ax-1 was an unprecedented mission that saw a fully private crew fly to the ISS. The crew was comprised of three Ultra High Net Worth Individuals (UHNWI) and a former NASA astronaut employed by Axiom Space. Each Ax-1 crewmember received over 700 hours of spaceflight training in addition to payload training. The crew completed twenty-five research investigations as well as media, outreach, and commercial events. **OVERVIEW:** The Axiom Medical Team (AMT) was charged with certifying these self-selected crewmembers for flight. Subsequently, the AMT presented to NASA and the International Partners (IPs) for risk acceptance. Significant integration was required to combine the medical operations of a commercial space entity with the existing processes used by NASA Medical Operations to fly government astronauts. The need to establish new medical processes drove the majority of the implementations by the AMT for Ax-1. **DISCUSSION:** In flying a fully private crew for a 17-day mission, Axiom had to develop a unique operational paradigm to support our suite of activities. It was quickly discovered that there is no "one size fits all" for Private Astronaut Missions (PAMs). Risk acceptance was predicated upon meeting NASA requirements and implementing new processes for a variety of medical needs. For example, Axiom worked with NASA to find a secure path for all PHI generated during the mission. This included agreements concerning medical imagery transfer, secure email processes, and payload science data management. Other operational challenges included:

- Coordination of exercise as a countermeasure to the effects of microgravity.
- Negotiating the timing and resource allocation required to facilitate on-orbit medical conferences.
- Establishing the division of medical authority among the medical teams at Axiom, NASA, and the US Commercial Vehicle provider during all phases of flight.
- Integration and assistance to facilitate commercial science endeavors.

Learning Objectives

1. The participant will be able to recognize some of the unique medical operational challenges faced by a commercial space company.
2. The participant will learn about strategies used to address the medical operational challenges faced during Axiom's Ax-1 mission.

[172] MEDICAL CERTIFICATION OF A MIXED COMMERCIAL CREW FOR SPACEFLIGHT, FROM SELECTION TO FLIGHT

John Marshall, Michelle Hong, William Powers

Axiom Space, Inc, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: The Axiom-1 (Ax-1) crew was comprised of three "Ultra High Net Worth Individuals" (UHNWI) and one veteran, Axiom employed astronaut. This mission demonstrated the successful medical certification of self-selected individuals that ultimately executed a successful mission of outreach and science. The Axiom-2 (Ax-2) mission again demonstrated a successful science and outreach mission but with a dramatically different crew contingent and medical selection process. **OVERVIEW:** In mid-2023, Axiom Space, Inc. launched Ax-2, its second mission to the International Space Station (ISS). The selected crew was especially diverse, comprised of one UHNWI, two government employed astronauts from the Kingdom of Saudi Arabia (KSA)-one of civilian and the other of military background-and one veteran, Axiom employed astronaut. The crew selection methods were also diverse. In contrast to Ax-1, the Ax-2 crew selection mixed UHNWI self-selection with an Axiom led selection campaign executed in cooperation with the KSA's then Saudi Space Commission (SSC). Axiom then undertook the final medical certification process of all Ax-2 crewmembers for risk acceptance by the National Aeronautics and Space Administration (NASA) and Multilateral Space Medicine Board (MSMB). In doing so, Axiom combined and applied known medical standards, aerospace medicine physician training and experience, and targeted medical consultant knowledge to assess astronaut medical

and mission risk and safely certify a multitude of medical comorbidities.

DISCUSSION: The Ax-2 mission represents a number of operational firsts, the most significant of which involves the first time a commercial space entity has led large scale medical selection efforts with a foreign government to select foreign government astronauts. In doing so, Axiom successfully collaborated with multiple government agencies to risk assess both career and non-career and government and private astronauts under one mission umbrella. These efforts required Axiom to establish a selection process that accommodated widely different customer backgrounds and mission goals in the face of diverse astronaut demographics.

Learning Objectives

1. The audience will understand the complexities of medically certifying commercial, private astronaut crewmembers for missions to the International Space Station.
2. The audience will understand the role that Axiom Space plays in advising burgeoning space agencies on the medical selection process.

[173] AX-3 MISSION SPECIFIC DETAILS

William (Ed) Powers¹, Mayur Bhakta², Alex Rubin², Michael Harrison¹

¹Hercules Medical Group/Axiom Space, Houston, TX, United States;

²Axiom Space, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: While the crew composition of missions Ax-1 and Ax-2 had Ultra High Net Worth Individuals (UHNWI's), by contrast Ax-3 have none. All crewmembers have extensive military aviation experience (three fighter pilots and a flight engineer). Four European countries are represented (Commander has dual citizenship) and Ax-3 is considered to be the first all-European space mission. **OVERVIEW:** In early 2024, Axiom Space will launch the Ax-3 mission. This is the third mission to dock with the International Space Station and NASA's third Private Astronaut Mission (PAM). The crew consists of the Commander who is an Axiom employee with dual citizenship (Spain and USA), a former Naval Aviator and an experienced NASA astronaut; the Pilot who is an Italian Air Force officer and fully trained as a Soyuz flight engineer; Mission Specialist 1 who is the first astronaut from Türkiye and a former fighter pilot and commercial airline pilot; and Mission Specialist 2 who is a Swedish fighter pilot and test pilot and was recently selected by the European Space Agency (ESA) as an astronaut. The Turkish astronaut underwent a selection process with collaboration between Axiom Space and the Turkish Space Agency, Tubitak Uzay. During the mission, experiments will be performed that are sponsored by the Italian Air Force, Tubitak Uzay, ESA and various other contributors. Much of the medical qualification tests were completed outside the US for two astronauts. All astronauts were approved for risk acceptance for flight to the International Space Station by the National Aeronautics and Space Administration (NASA) and the Multilateral Space Medicine Board (MSMB).

DISCUSSION: The Ax-3 mission has significant first-time milestones including: the first astronaut from Türkiye, the first all-European astronaut crew, the first use of NASA Launch Complex 40 for human spaceflight, and the first international partner flight surgeon to support a mission at Axiom (ESA flight surgeon). Additionally, to reduce reliance on limited NASA resources, Axiom has successfully established processes for providing and packing ascent/descent food and acquired in-house ownership of assets for secure communications between the ground medical team and the on-orbit crew.

Learning Objectives

1. The audience will learn about the distinctive crew of Ax-3, the third private astronaut mission to the International Space Station.
2. The audience will learn about the significant first-time milestones accomplished by the Ax-3 mission.

[174] FUTURE SIGHTS ON LONG DURATION MISSIONS: INTEGRATING MEDICAL SUPPORT WITH AX-4 AND BEYOND

John Marshall, Michelle Hong, Mayur Bhakta, Michael Harrison
Axiom Space, Inc., Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: The first three private astronaut missions (PAM) planned and executed by Axiom Space were of a diverse crew composition within and between missions. The first mission flew ultra-high net worth individuals while subsequent missions were composed increasingly of government agency astronauts. Just as the crewmember composition developed mission by mission, medical hardware and supply support similarly underwent an iterative process to accommodate the changing diversity of crew composition and mission parameters.

OVERVIEW: The current United States Carrier Vehicle (USCV) transporting astronauts to the International Space Station (ISS) includes a medical support kit to provide medical care during freeflight. Due to the extended nature of Axiom Space's current Private Astronaut Missions (PAM) involving docked missions to the ISS, additional medical supplies were included as part of a supplementary medical kit during the first Axiom PAM mission, Ax-1. Subsequent missions expanded on the Axiom Space provided medical supplies and crew training material and care delivery paradigms were developed to accommodate both medically experienced and inexperienced crewmembers from different cultural and agency backgrounds. For the Ax-4 mission to be flown, it is planned that the medical kit complement involves a further leap on the iterative design for parent containers, contents, and crew training. **DISCUSSION:** Along with plans for more new partnerships and crew compositions, the Ax-4 mission's medical support hardware and designs will pave the way for ground and flight testing for a minimum viable product for long duration, i.e. "Segment", operations integrated with the training and care delivery paradigms of an increasingly independent commercial space company. As the Ax-4 crew is to be determined at the time of this writing, all design and training instances will need to accommodate further diverse crew possibilities to include newly partnered agencies, e.g. the United Kingdom Space Agency. The tasks of creating de novo training materials, flight hardware testing and certification, and integration of processes with multiple agencies and crewmember backgrounds presents a particularly complex set of challenges that upon completion will push forward Axiom Space's long duration endeavors.

Learning Objectives

1. The audience will understand the iterative process of creating a crew medical support system that encompasses hardware, medications, training materials, and interagency dialogue.
2. The audience will understand the need for different training and care delivery paradigms that fit the mission type, crew composition, and interagency support.

Tuesday, 05/07/2024

Grand Ballroom A

2:00 PM

[S-33]: PANEL: MODELING G-INDUCED LOSS OF CONSCIOUSNESS (GLOC): A COLLABORATIVE CENTRIFUGE STUDY

Chair: Chris Dooley

PANEL OVERVIEW: High Performance Aircraft (HPA) in the Air Force and Navy place unique physical demands on their aircrew. Consequently, aircrew are at an ever-present risk of G-induced loss of consciousness (GLOC) when performing flight maneuvers. Pilots undergo substantial training to improve and maintain G-tolerance via centrifuge and live flight. Currently, there is limited ability for quantitative evaluation of HPA aircrew's physiologic resistance to, and real time risk of, GLOC and subsequently recovery. Recent improvements in physiologic sensing in flight open new avenues to explore real-time feedback of physiologic risk, including GLOC, for pilot safety and training effectiveness. Recruited from the WPAFB high-G human subject panel, participants experienced a simulated flight profile designed to safely and reliably induce GLOC. Participants were subjected to 3 spins with no aircrew flight equipment (AFE) and 3 spins with AFE. Data captured

during these events included heart rate, pupillometry, EEG, and pulse oximetry. Cognitive performance was assessed continuously via simultaneous visuomotor and math task to assess cognitive changes from pre-G exposure through G-loading and including post-G recovery. This study will result in improved models for real-time physiologic risk assessment for pilots, possibly preventing future mishaps and improving pilot training and performance. This collaborative study pulled expertise from Air Force and Navy subject matter experts, as well as leaning on support from academic partners. Multiple follow-on efforts are ongoing using the dataset generated. This panel will present an overview of the study design and execution as well as a subset of the primary analyses that are being completed with the data. Air Force representatives will present on the study design, physiologic presentation of GLOC, and model development for predicting cognitive deficit due to sustained Gz. Navy collaborators will present on the novel implementation of EEG under sustained Gz and model development for physiologic prediction of GLOC events. This study was reviewed and approved by the AFRL IRB.

[175] MODELING G-INDUCED LOSS OF CONSCIOUSNESS (GLOC): STUDY DESIGN AND EXECUTION

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(Original Research)

INTRODUCTION: USAF and USN High Performance Aircraft (HPA) place unique physical demands on aircrew. Consequently, aircrew are at an ever-present risk of G-induced loss of consciousness (GLOC) when performing flight maneuvers. Aircrew undergo training to improve and maintain G-tolerance via centrifuge and live flight. Currently, there is limited ability for quantitative evaluation of aircrew's physiologic resistance to, and real time risk of, GLOC and subsequent recovery. Improvements in physiologic sensing in flight open new avenues to explore real-time feedback of physiologic risk, including GLOC, for pilot safety and training effectiveness. WPAFB high-G human subject panel volunteers experienced centrifuge profiles designed to safely and reliably induce GLOC. Participants completed three spins with no aircrew flight equipment (AFE) and three spins with inflated AFE. **METHODS:** The study design was based off Tripp et al 2006 study exploring the same phenomena. The primary augmentations were inclusion of sensors with improved temporal resolution, EEG, and eye tracking. 13 volunteers from the WPAFB High-G Human Subject Panel combined to make 116 lab visits for task familiarization and data collection events. Volunteers were non-aircrew who've been 9G qualified in the WPAFB centrifuge. Subjects were outfitted with 16- or 32-lead BrainVision EEG, Tobii eye tracking glasses, NIRSense Aerie patch, and an Equivital Lifemonitor. Data collection profile consisted of a gradual onset rate exposure to capture daily baseline G-tolerance followed by a rapid onset rate (ROR) exposure to a threshold set above their daily G-tolerance. Participants simultaneously performed continuous visuomotor tracking and discrete arithmetic tasks before, during, and after the ROR. **RESULTS:** 75 data collection spins were successfully completed, 37 with no aircrew flight equipment (AFE) and 38 with inflated COMBAT EDGE system (anti-G suit, 55/P Helmet, MBU 20/P mask, and pressure breathing for G (PBG)). Of those spins, all 37 of the no AFE spins resulted in GLOC while only 8 of the AFE spins resulted in GLOC. **DISCUSSION:** The following presentations in this panel will highlight the insights that this dataset has enabled. Physiologic data collection in aerospace environments remains a challenge. However, the ability to collect high resolution, high quality physiologic data can unlock key insights into improving aircrew safety and performance.

Learning Objectives

1. Understand physiologic indicators of GLOC and their time course relative to the onset of sustained Gz forces.
2. Understand challenges and limitations to implementing physiologic sensors in the sustained Gz environment.

[176] MODELING G-INDUCED LOSS OF CONSCIOUSNESS (G-LOC): DETERMINATION BY AUDIOVISUAL CLUES - AGREE TO DISAGREE

Megan Gallo, Hannah Kohne, Lucas Potter, Christopher Dooley
Air Force Research Laboratory, Dayton, OH, United States

(Original Research)

INTRODUCTION: Historically, G-LOC events in human centrifuge exposures have been determined by observation from subject matter experts (SMEs). From 75 spins completed during this study, 45 G-LOC events were identified. The occurrence of G-LOC was determined via observation of live audio and camera feed from inside the centrifuge. This brief shall provide video examples of how the research team identified LOC through observation. Additionally, this brief will touch on the contentious debate of "almost" LOC. **METHODS:** For each G-LOC, three event times were recorded: time of suspected LOC, time of return to wakefulness, and time the participant resumed the visuomotor task. To identify LOC, researchers looked for indicators including dual eye closure, slumping of the head and upper body, and jaw muscle relaxation. Often, a combination of indicators occurred simultaneously with participants releasing a handbrake, and/or the head falling to the side or forward. The presence of aircrew flight equipment (AFE) did in some cases obscure determination of when or whether G-LOC had occurred. Return of wakefulness was identified by eyes reopening, sitting upright, and/or verbal feedback from the participant. Lastly, time to resumption of the task was identified by the participant replacing their hand on the joystick, and input on the task. The duration of time it took subjects to resume the visuomotor task also assisted in confirmation of whether G-LOC did in fact occur. After completion of the data collection session, the research team compared times, reviewed the video, and made a final determination of event times. Those event times were then merged into the physiologic and performance data files. **DISCUSSION:** Determination of LOC events in this study were consistent with previous work from Tripp et al. (2006) using similar indicators. Both efforts noted nuances in the phases of incapacitation, both absolute and relative. Comprehensive understanding of the phases of G-LOC are important in proper event determination, and ultimately aid in working towards protective measures for aircrew.

Learning Objectives

1. Audience will learn visual indicators of loss of consciousness (LOC).
2. Audience will learn about the phases of G-induced loss of consciousness (G-LOC).

[177] NEURAL MARKERS OF G-INDUCED LOSS OF CONSCIOUSNESS (GLOC) AND RECOVERY

Kara Blacker¹, Christopher Dooley²

¹Naval Medical Research Unit - Dayton, Wright-Patterson AFB, OH, United States; ²Air Force Research Laboratory 711th Human Performance Wing, Wright-Patterson AFB, OH, United States

(Original Research)

INTRODUCTION: Military aircrew in high-performance aircraft are often exposed to +Gz forces, resulting in a reduction of cerebral perfusion. Reduced blood supply to the brain can eventually lead to gravity-induced loss of consciousness (GLOC). GLOC incapacitates aircrew and even once consciousness is regained can severely impact safety and performance. While the physiological mechanisms that underlie GLOC itself are well characterized, prediction of impending GLOC and neurocognitive recovery following GLOC remain less understood. **METHODS:** Thirteen participants from the WPAFB high-G human subject panel participated in a total of 6 spins each. Along with other physiological measures, electroencephalography (EEG) was recorded. Participants completed a 5 min cognitive task before and after a rapid onset rate (ROR) profile intended to induce GLOC. Here, we report the EEG results during the time on task, during the GLOC, and return to consciousness phase. Power spectra were calculated

using a time-frequency transformation based on multiplication in the frequency domain from 1-30 Hz using a Hanning taper applied in short sliding time windows. **RESULTS:** From the onset of the ROR until GLOC, we observed a significant increase first in alpha power (8-13Hz), followed by a significant increase in theta power (4-7Hz). During GLOC, participants exhibited high delta power (1-3Hz), which is expected, as delta is most often associated with deep sleep. Interestingly, as participants regained consciousness, we saw the opposite effect, whereby first they transitioned from delta to theta, then theta to alpha. This cascade aligns with EEG characterization known from sleep research. Moreover, we compared frequency spectra for the cognitive task prior to the ROR and after the GLOC event. We found significant increases in delta and alpha following GLOC compared to before the ROR. This suggests that participants are not "back to baseline" for the 5 min following a GLOC event. **DISCUSSION:** Here, we were able to track individual's conscious awareness as before, during, and after GLOC. Evidence suggests there are neural indicators of impending GLOC that may be capitalized on for algorithm development and advancement of an early warning system. Moreover, delayed recovery of neurocognitive function following GLOC has implications for aircrew safety protocols.

Learning Objectives

1. Understand how EEG measures and tracks conscious awareness (or lack thereof).
2. Understand the neural markers that indicate impending GLOC, GLOC, and return to baseline.

[178] G-INDUCED LOSS OF CONSCIOUSNESS (GLOC) PREDICTIVE MODEL DEVELOPMENT

Bridget Rinkel¹, Chris Dooley², Kara Blacker³, Megan Gallo², Kim Cates⁴, Lucas Potter⁴, Hannah Kohne⁴, Adam Lammert⁵

¹Naval Air Warfare Center - Aircraft Division, Patuxent River, MD, United States; ²711th Human Performance Wing, Wright-Patterson AFB, OH, United States; ³Naval Medical Research Unit - Dayton, Wright-Patterson AFB, OH, United States; ⁴KBR, Dayton, OH, United States; ⁵Worcester Polytechnic Institute, Worcester, MA, United States

(Original Research)

INTRODUCTION: Military aircrew are often exposed to sustained +Gz in the high-performance cockpit, which can reduce cerebral blood volume and tissue oxygenation, putting aircrew at risk for G-Induced Loss of Consciousness (GLOC). GLOC can temporarily render aircrew unable to control their aircraft and is a major threat to aircrew safety and mission execution. Aircrew would benefit from having an early warning system that alerts them to impending GLOC based on data collected in operationally relevant environments. **METHODS:** Data collected from the 711th Human Performance Wing's GLOC study, including EEG, eye tracking, heart rate, and breathing rate, were used to develop machine learning-based models that provide accurate early indication of the onset of GLOC. Models tested included Random Forest, Support Vector Machine, and Ensemble Learning with Gradient Boosting. Three model systems were designed and evaluated against each other to predict impending GLOC: 1) in *unenrolled* participants, whose data the model had not been trained on, 2) in *enrolled* participants, whose data the model had been trained on, and 3) in enrolled participants, whose data were used to train personalized models, to predict impending GLOC based on individual physiology. Accuracy, efficiency, and operational relevance were evaluated and optimized across models. **RESULTS:** Models were able to predict impending GLOC up to fifteen seconds before it occurred. We found that the highest accuracies were obtained by training individual models for each participant based on individual physiology. The lowest accuracy measures were found in model system 1, which makes predictions on a participant's data it hasn't seen before based on other participant's physiology as GLOC approaches. **DISCUSSION:** We trained statistical models to predict impending GLOC based on physiological data collected in an operationally relevant environment

and demonstrated the tradeoff in model performance based on data collection and system objectives. The models help define the time course of development of GLOC from a physiologic, neurologic, and performance perspective, and allow identification of features with the strongest predictive power for real-time risk assessment.

Learning Objectives

1. The participant will understand which data contribute the strongest predictive power to detecting impaired aircrew physiological and cognitive functioning.
2. The participant will understand how variations in cross validation affect model performance.

[179] MODELING COGNITIVE PERFORMANCE DURING HIGH +GZ EXPOSURE

Kimberly Cates¹, Charles Fechtig², Chris Dooley³, Lucas Potter⁴, Kara Blacker⁵

¹KBR, Seton Hall University, Baltimore, MD, United States; ²University of Maryland, College Park, MD, United States; ³AFRL, Johns Hopkins University, Dayton, OH, United States; ⁴KBR, Old Dominion University, Dayton, OH, United States; ⁵Naval Medical Research Unit, Temple University, Dayton, OH, United States

(Original Research)

INTRODUCTION: G-force induced loss of consciousness (G-LOC) continues to be a risk in high-performance aviation with potential for aircraft destruction and more importantly, loss of life. Many studies have evaluated the physiological and anthropometric markers of G-tolerance to understand predictors of G-LOC; However, there's been limited success in predicting cognitive impairment in such simulated flight conditions. This paper provides an approach to modeling cognitive performance through identification of changes in physiological signals as subjects approach their G-tolerance threshold. **METHODS:** The study consisted of 13 participants who were 9-Gz qualified members of the High-G Acceleration (HGA) Human Subject Panel (HSP). Each participant had 6 runs in the centrifuge where half were with aircrew flight equipment (AFE), and half were without AFE. Participants first experienced a gradual onset run, 0.1 Gz/s, (GOR) to establish daily +Gz tolerance. The participants underwent a rapid onset run, 3.0 Gz/s, (ROR) where +2 Gz were added to the established +Gz tolerance threshold in the AFE condition and +1 Gz to the Non-AFE condition to induce G-LOC. During the ROR, participants were continuously performing a 2-part cognitive task, solving basic arithmetic operations while simultaneously tracking a reticle to a fixed target. The cognitive performance metric was calculated from these tasks to estimate the participant's executive functioning. Physiological signals (EEG, HR, PPG, and pupilometry) were evaluated for predictability of cognitive performance. Preprocessed EEG signals were transformed into Alpha, Beta, Theta, and Delta components and fed into the model as derived inputs. Other physiological signals such as pupil diameter, pupil velocity, and heart rate were also added. **RESULTS:** A long-short term memory (LSTM) neural network model learned how changes in physiological signals related to cognitive performance. A model (M1) was trained on all the runs and the following models focused on only runs with AFE, or Combat Edge, (AFE) (M2) and runs without AFE (M3). All models revealed high predictability of cognitive performance with RMSE scores between 0.014 - 0.020. **DISCUSSION:** Key characteristics of in-flight cognitive decline can be inferred by training the LSTM model on physiological changes. The cognitive performance model will allow for improved human machine teaming between pilot and aircraft to enhance safety and performance.

Learning Objectives

1. We will introduce previous attempts at modeling cognitive performance, how we preprocessed and aligned the sensors, and the associated limitations with preparing the data.
2. Identify physiological markers of cognitive performance, understand how to measure cognitive performance, and review LSTM model training and validation.

3. Understand challenges and limitations to modeling cognitive performance given manual data collection, sensor technicalities, and individual differences.

Tuesday, 05/07/2024
Grand Ballroom B

2:00 PM

[S-34]: PANEL: INTERNATIONAL PANEL ON SCREENING FOR HEART DISEASE IN AIRCREW

Chair: Eddie Davenport

PANEL OVERVIEW: INTRODUCTION: *Heart disease is one of the leading causes of medical disqualification in aircrew. Screening for heart disease to prevent sudden incapacitation is controversial and published guidelines do not take into consideration high risk occupations such as aviation. Furthermore, specific features of military aviation (such as +Gz, positive pressure breathing, air combat sorties) place high levels of stress on the cardiovascular system. Determining the acceptability of cardiovascular disease in military aviation is challenging given the paucity of evidence and limited number of military aviation cardiologists. TOPIC: This panel will consist of 5 countries presenting current standards for cardiac screening in aircrew. Topics will include Arrhythmias to include ventricular pre-excitation, channelopathies, valvulopathies, cardiomyopathies to include athletic heart, and coronary artery disease to include anomalous coronary arteries. We will conclude with a moderated discussion with the 5-country panel to foster ongoing collaboration to establish an evidence-based consensus working group to develop international screening guidelines for heart disease in pilots and other high-risk occupations. APPLICATION: Screening for heart disease in aircrew and other high-risk occupations is often overlooked and ill-defined. International consensus in aerospace medicine prevention is necessary in the modern era of air and space travel. This also provides a unique opportunity for the flight surgeon or aeromedical examiner to not only ensure safety of flight but possibly save a life through prevention.*

[180] SCREENING FOR ARRHYTHMIAS TO INCLUDE VENTRICULAR PRE-EXCITATION IN UNITED STATES AIRCREW

Eddie Davenport

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Heart disease is one of the leading causes of medical disqualification in aircrew. Screening modalities include echocardiogram to look for structural heart disease, ECG to look for electrical abnormalities/arrhythmia, and exercise stress testing to look for coronary artery disease. Unlike traditional risk factors for coronary artery disease, arrhythmias to include ventricular pre-excitation may be more prevalent in active and athletic individuals and thus screening is essential yet difficult. Furthermore, much debate exists in screening ECGs, ambulatory cardiac monitors, and stress testing. There are no established guidelines for arrhythmia screening in aircrew, however the US military has undergone many revisions of screening policy in the past 50 years. **TOPIC:** Screening for arrhythmias will be discussed in detail to include the current guidelines from the US Preventive task force as well as the American College of Cardiology and American Heart Association. Special attention will be made to athletic guidelines and the relevance to military aircrew. Current United States Air Force arrhythmia screening policy will be discussed. FAA and NASA policy will also be mentioned and evidence-based recommendations for ongoing research and collaboration to establish a more universal, formal, and evidence-based screening protocol will be discussed. **APPLICATION:** Arrhythmias are very common and can lead to sudden incapacitation and thus aircrew should be screened; however, modality and frequency are very controversial and no consensus has been established even within countries. This presentation will discuss USAF recommendations and need for ongoing evidence based international collaboration.

Learning Objectives

1. Understand the importance of screening for arrhythmia in aircrew to prevent sudden incapacitation.
2. Screening for arrhythmia is often overlooked and ill-defined without international guidelines. Heart disease guidelines for military and commercial pilots should be developed through an international working group of aerospace physicians and cardiovascular subspecialists.
3. Aeromedical Examiners and flight surgeons have a unique opportunity to screen for and even prevent heart disease thus ensuring safety of flight and saving lives.

[181] AEROMEDICAL ASSESSMENT OF MILITARY PILOT APPLICANTS – DETECTION AND MANAGEMENT OF CHANNELOPATHIES

Norbert Guettler

German Air Force Centre of Aerospace Medicine, Cologne, Germany

(Education - Tutorial/Review)

INTRODUCTION: Due to the challenging working environment of military pilots, applicants undergo a profound cardiovascular screening with a slightly different profile in different nations. Channelopathies are examples for inherited cardiac diseases, which might be detected during screening and potentially affect young people. These diseases are usually caused by transmembrane ion channel or protein mutations involved in intracellular calcium handling and can possibly lead to ventricular tachyarrhythmia and sudden cardiac death. The German screening policy for military pilot applicants will be explained using the example of channelopathies. **TOPIC:** Cardiovascular screening of military pilot applicants in Germany includes medical history, physical examination, laboratory testing, ECG, exercise ECG, transthoracic echocardiography, and Duplex sonography of the carotid arteries. Additional examinations may be performed on indication. Channelopathies including Brugada syndrome, congenital Long QT syndrome, Short QT syndrome, Catecholaminergic Polymorphic Tachycardia syndrome, and malignant Early Repolarization syndrome are rare, but are not compatible with flying in many cases even if asymptomatic. Early diagnosis and risk assessment is therefore of utmost importance and will be explained along with treatment options for risk mitigation. Risk stratification and treatment should be performed in specialist centers using international guidelines and can be very challenging. **APPLICATION:** Cardiovascular screening of military pilot applicants is important despite their mostly young age. Screening policies are slightly different among nations, differences will be discussed in the panel with the aim to achieve a multinational consensus. Screening profiles for military pilot applicants can be used as an example for screening in other high-risk occupations including divers, emergency workers, mountaineers, and commercial drivers with variations depending on the respective profession.

Learning Objectives

1. Learn the importance of cardiovascular screening in military pilot applicants and other high-hazard occupations.
2. Learn that cardiac channelopathies are a group of inherited ion channel diseases possibly leading to ventricular tachyarrhythmia and sudden cardiac death in young people.
3. Learn ECG criteria of Brugada syndrome, congenital Long QT syndrome, Short QT syndrome, and Early Repolarization syndrome, as well as differences between benign and malignant Early Repolarization syndrome.

[182] VALVULOPATHIES IN AIRCREW

Thomas Syburra¹, Norbert Guettler², David Holdsworth³, Denis Bron⁴, Lysette Broekhuizen⁵, Olivier Manen⁶, Eddie Davenport⁷

¹Hôpital de La Tour, Meyrin/Geneva, Switzerland; ²German Air Force, Cologne, Germany; ³British Army, London, United Kingdom; ⁴Swiss Air Force, Dubendorf, Switzerland; ⁵Dutch Air Force, Amsterdam, Netherlands; ⁶French Air Force, Paris, France; ⁷U.S. Air Force, Centerville, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Aeromedical risk is determined by aeromedical standards, which aim to eliminate individuals with identifiable medical risk from air operations. The assessment has the potential to lead to medical disqualification. Cardiovascular disease is responsible for half of all aircrew licenses declined in the Western world and is the leading cause of sudden incapacitation. As the retirement age from active flying continues to increase, more aircrew are at risk of developing relevant cardiovascular diseases. **TOPIC:** Valvular heart disease (VHD) is relevant to aircrew because it may limit the appropriate augmentation of cardiac output, especially in high-performance flying, and it predisposes to arrhythmias. Aircrew with VHD need close follow-up to ensure their fitness to fly. Concomitant aortopathy may be found, especially in the presence of bicuspid aortic valves (BAV). The gold standard of care for VHD particularly when associated with aortic disease as seen in conjunction with BAV, remains currently open-heart surgery within the age range of active flying duties. Yet, the right choice of surgical procedure (e.g. mechanical versus tissue valve prosthesis in aortic VHD, repair rather than replacement in mitral VHD, left atrial appendage exclusion, among others) is key for medical license renewal. Restrictions on aircrew duties, especially on high-performance airframes or solo flying, are usually required. **APPLICATION:** To mitigate avoidable license withdrawal or limitations, optimal communication and coordination between the flight surgeon and the heart surgeon is paramount.

Learning Objectives

1. To understand the primary importance of valvular heart disease in aircrew.
2. To appreciate the current surgical therapeutic options in accordance to the aeromedical regulations and the surgical guidelines.
3. To understand the licensing limitations after open heart surgery and their mitigation through the right assessment modalities, the use of current surgical techniques and the communication between all the involved partners

[183] ATHLETIC HEART AND CARDIOMYOPATHIES

Lysette Broekhuizen¹, Norbert Guettler², Denis Bron³, David Holdsworth⁴, Olivier Manen⁵, Thomas Syburra³, Joanna d'Arcy⁶

¹Central Military Hospital/University Medical Center Utrecht, Zeist, Netherlands; ²German Air Force Center for Aerospace Medicine, Cologne, Germany; ³Aeromedical Centre, Swiss Air Force, Dübendorf, Switzerland; ⁴Royal Army, RAF Aviation Clinical Medicine Service, RAF Centre of Aviation Medicine, RAF Henlow, United Kingdom; ⁵Aviation Medicine Department, Aeromedical Centre, Percy Military Hospital, Clamart, France; ⁶RAF Aviation Clinical Medicine Service, RAF Centre of Aviation Medicine, RAF Henlow, United Kingdom

(Education - Tutorial/Review)

INTRODUCTION: Differentiating cardiomyopathies (hypertrophic or dilated) from exercise related remodeling can be a challenge for the aeromedical examiner and cardiologist. Cardiac remodeling induced by exercise is an adaptive increase in cardiac chamber size and wall thickness that is promoted by the physiological demands of exercise, often referred to as the 'Athletes heart'. **TOPIC:** Regular high intensity exercise promotes structural, functional, and electrical changes of the heart, this rarely leads to adverse clinical effects, such as the onset of arrhythmias or sinus node dysfunction. In patients with a genetic predisposition for certain cardiomyopathies (CMP), mainly arrhythmogenic cardiomyopathies or ACM: Arrhythmogenic right ventricular cardiomyopathy (ARVC), arrhythmogenic dilated cardiomyopathy (DCM) and biventricular arrhythmogenic cardiomyopathy, it has been suggested that exercise can promote early development of arrhythmia and pathological alterations, mainly of the RV, and therefore high performance activities usually need to be discouraged. As both entities can look very similar, differentiating the trained athletes heart with 'physiological' remodeling from

pathological structural changes associated with inherited and acquired cardiac disorders calls for experience together with good diagnostic techniques. CMR is the gold standard for evaluating left and right ventricular function, giving detailed information on presence of regional wall motion abnormalities, myocardial thinning, and ventricular aneurysms. Additional late gadolinium enhancement (LGE) images detect edema and fibrosis which can be used for prognostic purpose. Holter monitoring and exercise testing in order to screen for arrhythmias or conduction disorders are pivotal additional diagnostic methods. Prior to medical investigation it is needed to perform a thorough interview asking about symptoms and family history of cardiovascular disease and sudden cardiac death (SCD). If the family history is positive genetic counseling may help to further determine the diagnosis. **APPLICATION:** However rare, recognizing real CMP from the athletes heart in aircrew is essential as heart muscle disease can lead to acute incapacitation or even SCD, but also to determine treatment goals. On the other hand, misdiagnosing an athletes heart calling it cardiomyopathy can have a serious impact on someone's career and lead to unnecessary restrictions.

Learning Objectives

1. To understand why it is useful to screen aircrew for myocardial disease and know the different types of cardiomyopathy and their complications.
2. To understand that exercise induced remodeling of the heart can mimic cardiomyopathies and learn how to differentiate between "normal" cardiac adaption to sports and pathology.
3. To learn about diagnostic strategies that can be used to determine cardiovascular risk.

[184] INTERNATIONAL PANEL ON INITIAL SCREENING FOR HEART DISEASE IN AIRCREW - CORONARY ARTERY DISEASE AND CORONARY ARTERY ANOMALIES

David Holdsworth¹, Lysette Broekhuizen², Denis Bron³, Norbert Guettler⁴, Olivier Manen⁵, Thomas Syburra³, Eddie Davenport⁶

¹University of Oxford, Oxford, United Kingdom; ²Central Military Hospital/University Medical Center Utrecht, Utrecht, Netherlands; ³Aeromedical Centre, Swiss Air Force, Dübendorf, Switzerland; ⁴German Air Force, Cologne, Germany; ⁵Aeromedical Centre, Percy Military Hospital, Paris, France; ⁶U.S. Air Force, Centreville, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Appropriate screening of aircrew applicants for coronary artery disease is challenging. The majority of evidence for diagnosing coronary artery disease is drawn from symptomatic patients presenting with exertional chest pain. Where evidence does exist for asymptomatic groups, or guidance has been provided for primary prevention of coronary disease, this is often appropriate for middle-aged individuals who still may not reflect the typical professional aviation applicant. **TOPIC:** The clinical history and physical examination continue to provide the bedrock of appropriate screening for both premature coronary artery disease and anomalous coronary origins. A detailed history of episodes of collapse (especially mid-exertion); concerning family history of premature coronary disease; cardiac or unexplained death at a young age and smoking history are essential. The use of population-based 10-year cardiovascular risk estimates is appropriate for older applicants. These will often require blood tests to identify/exclude dyslipidemia. Young applicants are at such a low absolute risk of coronary events that exercise ECG is generally unhelpful due to the high false positive rate, while CACS misses non-calcified plaque which is important in the young/middle-aged. Applicants who are at high risk would be excluded from flying on the basis of this risk. This leaves the group with intermediate risk. The question remains for middle-aged applicants whose population-based risk score indicates

borderline/intermediate risk: can exercise ECG, functional imaging or some form of gated CT imaging enhance risk stratification to improve not only clinical management but also occupational recommendation? There is a trans-Atlantic difference in the uptake of gated cardiac CT between full CT angiography (CTCA) and coronary-artery calcium scoring (CACS). Given that calcification of coronary atheroma is known to occur at a later stage in the natural history of coronary atherosclerosis, it seems reasonable to propose that CTCA may outperform CACS (insensitive to non-calcified plaque) in early discovery of coronary disease in a younger group. **APPLICATION:** SCOT HEART II and ORFAN aim to reveal whether there is any incremental advantage of CTCA over CACS. The results may lead to significant changes in the CAD screening potential of both patients and aircrew applicants.

Learning Objectives

1. To understand the primary importance of pretest probability to appropriate investigation for coronary artery disease in asymptomatic aircrew applicants.
2. To appreciate the fallacy of focusing on determining the presence or absence of an anatomical coronary narrowing (stenosis) rather than establishing the likelihood of a coronary event. This is the false elevation of anatomy over clinical outcome.
3. To understand the relative advantages and disadvantages of full-gated CT coronary angiography over coronary artery calcium scoring in the identification of coronary atherosclerosis and the potential of future radiomic markers of coronary artery inflammation in prediction of coronary events.

Tuesday, 05/07/2024

2:00 PM

Grand Hall J

[S-35]: SLIDES: UNDERSTANDING FACTORS IN MENTAL HEALTH

Chair: Mary Cimrmancic

Co-Chair: Adam Sirek

[185] UNDERSTANDING FACTORS THAT INFLUENCE MENTAL HEALTHCARE AVOIDANCE IN US PILOTS AND SOLUTIONS FOR THE FUTURE: CIVILIAN TRAINEE PILOT PERSPECTIVE

Elizabeth Bjerke, Joelle Ruthig

University of North Dakota, Grand Forks, ND, United States

(Original Research)

INTRODUCTION: Evolving data suggest that a population pilots participate in healthcare avoidance behavior due to fear or loss of flying status. The factors that influence healthcare seeking behavior in trainee pilots remain uncertain. The objective of this study was to conduct an assessment of trainee pilots' perceptions on seeking healthcare (physical and mental) in order to identify factors that (1) uniquely discourage/encourage disclosure, (2) understand factors that aid the aeromedical provider/aviator relationship, and (3) identify interventions that could be implemented to address discouraging factors. **METHODS:** A qualitative assessment was conducted to evaluate civilian trainee pilots' perceptions on health care seeking services. 20 semi-structured interviews with commercial aviation students at a large U.S. based collegiate aviation university were conducted, transcribed and synthesized as part of this research process. Interview transcriptions underwent thematic content analysis by two independent researchers, which involves deriving concepts from data and comparing them with other data to facilitate meaningful categorization. **RESULTS:** The analysis of the qualitative data revealed multiple themes that influence healthcare seeking in this population. Many of the themes that emerged were negative barriers perceived by pilots that could impact their progression and future careers in aviation. It was also found that misunderstanding and lack of information/communication play a pivotal role to pilot healthcare seeking behavior. **DISCUSSION:**

Factors that influence trainee pilot healthcare seeking behavior are heterogeneous. Understanding these factors may permit the generation of interventions and strategies to address pilot healthcare avoidance. Increasing access and education in regards to aeromedical screening is important for civilian pilot trainee decision making to seek help, as well as a focused effort to streamline the process for increased efficiencies. These findings are uniquely pertinent in the setting of rising rates of reported mental health concerns in a younger generation of pilots.

Learning Objectives

1. The audience will understand the perceptions and influences of civilian pilot trainees in regards to healthcare seeking behavior of pilots.
2. The audience will learn of strategies and interventions aimed to improve the decision making of civilian pilot trainees in seeking appropriate healthcare solutions.

[186] WHAT FACTORS INFLUENCE HEALTHCARE SEEKING BEHAVIORS AMONG U.S. AIR FORCE PILOTS?

Rachael Martinez¹, Tanya Goodman², Christopher Thompson³, William Hoffman⁴

¹USAFSAM, Wright-Patterson AFB, OH, United States; ²Neurostat Analytical Solutions, LLC, Great Falls, VA, United States; ³U.S. Air Force, Dayton, OH, United States; ⁴59th Medical Wing, San Antonio, TX, United States

(Original Research)

INTRODUCTION: Unlike airline transport pilots, military pilots on duty not including flying status are assigned other non-flying duties such as administrative work and their status does not impact their pay, but recent research has shown that military pilots also participate in healthcare avoidance behavior. **METHODS:** We conducted qualitative interviews with U.S. Air Force (USAF) pilots using a semi-structured interview guide to collect firsthand accounts and perspectives of (1) factors that support mental healthcare seeking and health information disclosure, (2) factors that discourage those behaviors, and (3) potential solutions to address pilot healthcare avoidance. Interview transcriptions underwent thematic content analysis by two independent researchers that involved deriving concepts from data and comparing them with other data to facilitate meaningful categorization. **RESULTS:** We conducted 21 interviews lasting an average of 30 min with USAF pilots. There were 138 pages of transcript, and code saturation occurred after 13 interviews. The most reported factors that discourage military pilot healthcare disclosure and healthcare utilization overall were medical revocation (90%, n = 19/21), stigma (90%, n = 19/21), and lack of trust in providers (43%, n = 9/21). Unit embedded services (81%, n = 17/21), ease of access (48%, n = 10/21), and severity of condition (38%, n = 8/21) were the most reported factors encouraging disclosure and utilization. The top-reported recommendations from pilot interviewees were increased flight doctor accessibility (57%, n = 12/21) and education/support of policies (33%, n = 7/21).

DISCUSSION: This is the first in-depth, systematic exploration of pilot perspectives on healthcare disclosure and utilization in the USAF. The results of this study will be used to shape USAF line and medical leadership strategies geared toward improving embedded mental healthcare capabilities for pilots in tip-of-the-spear communities.

Learning Objectives

1. The participant will be able to understand the factors that influence mental healthcare avoidance behaviors among military pilots.
2. The audience will learn about potential solutions for encouraging disclosure of health symptoms and utilization of healthcare services among military pilots.

[187] A QUALITATIVE ASSESSMENT OF FACTORS THAT INFLUENCE MENTAL HEALTHCARE SEEKING AND HEALTH INFORMATION DISCLOSURE IN US AIRLINE PILOTS

William Hoffman

Columbia University Medical Center, New York, NY, United States

(Original Research)

INTRODUCTION: US airline pilots are required to meet certain medical standards to maintain their flying status. Evolving data suggest that a portion of US airline pilots participate in healthcare avoidance behavior due to fear for loss of flying status, which has the potential to influence pilot health, the effectiveness of aeromedical screening and safety. The factors that influence US airline pilot mental healthcare seeking behavior and information disclosure remain unknown. **METHODS:** We conducted qualitative interviews with airline pilots using a semi-structured interview guide to collect firsthand accounts and perspectives of (1) factors that support mental healthcare seeking and health information disclosure, (2) factors that discourage those behaviors, and (3) potential solutions to address pilot healthcare avoidance. Interview transcriptions underwent thematic content analysis by two independent researchers, which involves deriving concepts from data and comparing them with other data to facilitate meaningful categorization. **RESULTS:** We conducted 36 interviews lasting an average of 30-35 minutes with US airline pilots. There were 268 pages of transcript and code saturation occurred after 25 interviews. The most reported discouraging factors for pilot healthcare disclosure and utilization were medical revocation (97%, n=35/36), policy misinformation and lack of education (44%, n=16/36), and stigma (39%, n=14/36). The most reported encouraging factors were peer support services (33%, n=12/36), company support (33%, n = 12/36), and union embedded medical resources (31%, n = 11/36). Proposed solutions included addressing culture surrounding mental health (72%, 26/36), education about medical certification policies (47%, 17/36), and medical certification processing times (25%, 9/36). **DISCUSSION:** The factors that influence mental healthcare seeking and health information disclosure in US airline pilots are highly heterogeneous. In our study, there were multiple modifiable factors identified by pilots that could support healthcare seeking and information disclosure. Further research should focus on conducting safety analyses of efforts aimed at addressing factors that negatively influence these behaviors.

Learning Objectives

1. Describe two factors that support mental healthcare seeking and health information disclosure in US airline pilots.
2. Describe two factors that discourage mental healthcare seeking and health information disclosure in US airline pilots.

[188] A QUALITATIVE LOOK AT THE PERSPECTIVES OF FEMALE U.S. COMMERCIAL PILOTS: CONTINUED BARRIERS IN SEEKING HEALTHCARE

Tanya Goodman¹, Nicole Devlin¹, Rachael Martinez², Christopher Thompson², Billy Hoffman³

¹Neurostat Analytical Solutions, LLC, Great Falls, VA, United States;

²Wright-Patterson AFB, OH, United States; ³59th Medical Wing, San Antonio, TX, United States

(Original Research)

INTRODUCTION: Data indicate that pilots express high anxiety around seeking healthcare, seen across sex and age, resulting in pilots withholding information from their physicians and delaying seeking medical care. These barriers to seeking healthcare were seen across male and female aviators, but there is little research on the unique concerns female aviators have when it comes to seeking healthcare and maintaining their flight status. **METHODS:** We conducted qualitative interviews with airline pilots using a semi-structured interview guide to collect firsthand accounts and perspectives of (1) factors that support mental healthcare seeking and health information disclosure, (2) factors that discourage those behaviors, and (3) potential solutions to address pilot healthcare avoidance. Interview transcriptions underwent thematic content analysis by two independent researchers that involved deriving concepts from data and comparing them with other data to facilitate meaningful categorization. **RESULTS:** From the total sample of 36 interviews with U.S. airline pilots, there was a subset of 12 female airline pilots. Female pilots reported that medical revocation (92%, n = 11/12),

stigma (58%, n = 7/12), and policy misinformation and lack of education (42%, n = 5/12) were the overall biggest factors that discouraged healthcare disclosure and utilization. The most reported encouraging factors were peer support services (50%, n = 6/12), third party resources (33%, n = 4/12), and union embedded medical resources (25%, n = 3/12). Recommendations from this sub-sample of airline pilots centered around changes with the female experience in mind or family-oriented concerns (e.g., adjust Federal Aviation Administration policies on women's health).

DISCUSSION: Results suggest that female pilots want work environments that foster inclusivity and acknowledgment of their diverse needs. Their suggestions reflect a need for a cultural shift in their work environments, a need for acknowledgment and understanding of the differences in health needs of men and women, and a need for more attention given to clarifying, expanding, updating, and disseminating information about healthcare policies and processes.

Learning Objectives

1. The presenter will help the audience see the need for acknowledgment and understanding of the differences in health needs of men and women.
2. The presenter will help the audience understand the need for more attention given to clarifying, expanding, updating, and disseminating information about healthcare policies and processes.

Tuesday, 05/07/2024
Grand Hall K

2:00 PM

[S-36]: PANEL: RESIDENT IN AEROSPACE MEDICINE (RAM) GRAND ROUNDS II

Chair: Serena Auñón-Chancellor

Co-Chairs: Thomas Jarnot, Sonya Heidt

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

[189] GIANT CELL TUMOR IN A MILITARY AVIATOR: A CASE REPORT

David Smith, William Smith

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case describes a military aviator diagnosed with giant cell tumor of bone (GCTB) of the right leg following evaluation for chronic right knee pain with running. **BACKGROUND:** GCTB is a rare, locally aggressive non-cancerous tumor of the bone that typically occurs between 20-40 yr of age, with a slight female predilection. Approximately 50% occur in the distal femur or proximal tibia, although also found in the ulna, proximal femur, humerus, and spine. Localized pain is the most common presenting symptom, usually associated with activity, relieved with rest, and progressively worsens over time. While typically benign, GCTB can grow quickly and affect nearby joints. Metastases to the lung may occur but is usually in the setting of locally recurrent disease; malignant transformation is less than 1%. Pathologic fracture occurs occasionally. Surgical excision is the preferred treatment for GCTB, although radiation, tumor embolization, or monoclonal antibody injection may be used in cases not amenable to surgery. **CASE PRESENTATION:** This pilot presented in his mid-30s with 2 yr of progressively worsening right knee pain that was limiting his ability to run. Failure of conservative management led the patient to seek care. Initial plain film imaging was

remarkable for a 6.7-cm cystic lesion. Suspicion of GCTB was confirmed with computed tomography-guided biopsy. The patient underwent excision of the entire tumor with curettage, bone grafting, and plating. He gradually returned to full symptom-free activity and was returned to flying status with waiver. **DISCUSSION:** GCTB is a rare but aeromedically significant disorder requiring careful consideration. Benign neoplasms are disqualifying within the U.S. Air Force when the condition prevents satisfactory performance of duty or is not remediable/refused, ongoing specialty follow-up is prohibitive, or the tumor is likely to enlarge or has malignant potential. All military branches note that symptomatic retained hardware may be disqualifying. Civilian standards do not specifically address benign tumors of the bone. Symptomatic GCTB can be disqualifying, and aeromedical decisions should be made after careful evaluation of the precipitating factors and success of treatment. In this case, the waiver authority considered the aviator's stability and demonstrated ability in making the decision.

Learning Objectives

1. Ensure aerospace medicine clinicians consider giant cell tumor and other pathologic disorders in their differential diagnosis when evaluating aviators with complaints of knee pain.
2. Review the common considerations for giant cell tumor as it pertains to the aeromedical environment.

[190] I CAN SEE CLEARLY NOW: FIGHTER PILOT WITH CENTRAL SEROUS RETINOPATHY

Monica Pierce Wysong, Lyndsey Vu
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case report describes a pilot diagnosed with central serous retinopathy (CSR) after complaining of visual distortion. **BACKGROUND:** CSR occurs when fluid builds up under the retina, causing a small detachment leading to vision changes. CSR is more likely in middle-aged men and more common in those with Type A personality, chronic corticosteroid use, obstructive sleep apnea, and autoimmune disorders. **CASE PRESENTATION:** A 31-yr-old otherwise healthy experienced male fighter pilot presented to flight medicine complaining of distortion of lines and blurring of a portion of the visual field in his right eye. He was referred to optometry; fluid was seen in the macular region on optical coherence tomography. He was diagnosed with CSR and advised to decrease stressors. Eplerenone was initiated 6 wk later due to persistent symptoms with resolution of both clinical symptoms and objective findings on optical coherence tomography. He was granted a waiver after full resolution of the condition, cessation of medication, and recommendation by the Aeromedical Consultation Service. **DISCUSSION:** The average age of pilots in the United States in 2020 was 43.9 yr. As CSR is seen mostly in males 30-50 yr old, aerospace medicine specialists should have a low threshold for suspicion of this condition. Recurrence can be as high as 50% in untreated individuals. Overactivation of mineralocorticoid receptors by corticosteroids leading to choroidal vasodilation is the proposed pathogenesis for the disease. Intranasal steroids are used frequently for allergic rhinitis and are generally considered to have few systemic symptoms. However, while corticosteroid use has an odds ratio of 4.29 for CSR, nasal/inhaled steroids have an odds ratio of 2.44 based on a meta-analysis of 17 studies. Eplerenone works as a mineralocorticoid receptor antagonist and has the benefit of decreasing fluid thickness. The Aeromedical Consultation Service recommends initiating eplerenone at initial diagnosis to decrease duration of symptoms and earlier waiver potential. Aviators with CSR should be screened for autoimmune disorders, *H. pylori* infection, hypertension, and obstructive sleep apnea. Stress management for all aviators should be discussed at annual visits, and counseling on the risk of nasal steroids should highlight systemic risks, including CSR for aviators.

Learning Objectives

1. The audience will understand the diagnosis of Central Serous Retinopathy (CSR), its pathophysiology, and comorbid conditions.

2. The audience will understand the treatment modalities of CSR with a focus on eplerenone, which may decrease time to waiver.

[191] AN ACOUSTIC NEUROMA RESULTING IN SUDDEN UNILATERAL HEARING LOSS IN AN AIR BATTLE MANAGER: A CASE REPORT

Clifford Nolt, Cameron Conard
Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case report describes a sudden episode of unilateral hearing loss in an Air Battle Manager leading to the diagnosis and treatment of an acoustic neuroma. **BACKGROUND:** Acoustic neuromas have an increasing incidence of 4.2 in every 100,000 person-years in the last decade. Early diagnoses tend to lead to a better prognosis, as treatment can be less invasive with a quicker recovery for small tumor size. **CASE PRESENTATION:** A 35-yr-old Air Battle Manager presented to a local urgent care with sudden unilateral hearing loss while on temporary duty in September 2021. He was prescribed steroids with no improvement the following day. His primary care manager ordered a magnetic resonance imaging of his brain and internal auditory canals to evaluate for structural etiologies of his hearing loss. The imaging revealed a mass on the right acoustic nerve with features consistent with vestibular schwannoma (acoustic neuroma). After evaluation by Otolaryngology and discussion of treatment options, he underwent 5 rounds of gamma knife treatment in December 2021. Follow-up imaging in December 2022 showed a reduction in tumor size, and the member's hearing had returned to H1 hearing. He was ultimately granted a waiver for 1 yr, with possibility of extending beyond 1 yr on next review with demonstrated stability. **DISCUSSION:** The case highlights the importance of having a high suspicion for an acoustic neuroma in the presence of sudden asymmetric hearing loss, as a delay in diagnosis could lead to an increase in tumor size and a need for more invasive treatment. If an early diagnosis can be made, less invasive treatments—such as linear accelerator or gamma knife radiosurgery—can be used, with a quicker recovery and shorter grounding time for the individual. Early treatment can also help prevent permanent neurologic sequelae that would interfere with the member's ability to perform required duties.

Learning Objectives

1. Recognizing the symptoms of an acoustic neuroma and other causes of sudden unilateral hearing loss to prevent delay in diagnosis.
2. Understand how this condition can be treated to minimize the impact on a member's aviation status and career.

[192] MEDICAL RISK ASSESSMENT IN A HYPOTHETICAL LUNAR CREWMEMBER WITH SEVERAL CHRONIC MEDICAL CONDITIONS

Michael LaBarbera¹, Craig Kutz¹, Matthew Makowski¹, James Pattarini², Serena Auñón-Chancellor¹

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

(Education - Case Study)

INTRODUCTION: This hypothetical case report presents operational and medical considerations of certifying an experienced astronaut with several stable chronic medical conditions assigned to a long-duration spaceflight mission to the lunar surface. **BACKGROUND:** Pre-flight aeromedical risk assessment aims to optimize astronaut crew performance by minimizing the likelihood of in-flight medical emergencies. Future lunar missions will likely employ novel ambient pressures and oxygen partial pressures to enable frequent sorties to the lunar surface, which present unique physiologic stresses and operational considerations. Including more experienced astronaut crew on such missions would likely improve mission performance, though it is not yet known how the

unique environmental and operational exposures of a lunar surface mission might influence aeromedical risk in individuals with chronic, stable medical conditions. This case report presents aeromedical risk assessment for a hypothetical astronaut crew with mildly elevated cardiovascular risk and considerations in chronic hypobaric and hypoxic exposure. **CASE DESCRIPTION:** A hypothetical 55-year-old female mission specialist is chosen to participate as prime crew for a 3-week duration lunar surface mission. She is highly experienced with two prior long-duration spaceflights including several prior mission extra vehicular activities. On her preflight physical, she is noted to have mildly elevated cardiovascular risk based on coronary artery calcium (CAC) score and elevated serum lipids, though has no history of cardiac arrhythmia and no significant family history of cardiovascular disease. Further cardiovascular evaluation is negative, and her prior annual physical was notable for stage I hypertension that is well controlled with diet and exercise. **DISCUSSION:** Future spaceflight missions to the lunar surface will greatly benefit from the operational experience of experienced astronaut crewmembers, though it is not known how the unique ambient pressure and oxygen tension of that environment may impact crew health and performance in individuals with existing chronic medical conditions. We present considerations for aeromedical risk assessment of an individual with cardiovascular risk factors operating within a unique ambient environment on the lunar surface.

Learning Objectives

1. The audience will gain an appreciation for potential aeromedical considerations of cardiovascular risk factors in future lunar missions.
2. The audience will gain an appreciation for the impact of spaceflight, crew performance, and health risks of cardiovascular risk factors in future lunar missions.

[193] A HYPOTHETICAL CASE OF DECOMPRESSION SICKNESS DURING LUNAR SURFACE EXTRAVEHICULAR ACTIVITY AND RETURN TO DUTY CONSIDERATIONS

Craig J. Kutz¹, Matthew S. Makowski¹, Michael A. LaBarbera¹, James M. Pattarini², Serena M. Auñón-Chancellor¹

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

(Education - Case Study)

INTRODUCTION: This case report presents a hypothetical lunar decompression sickness (DCS) event with consideration of treatment approach and disposition. **BACKGROUND:** Lunar extravehicular activities (EVA) pose a risk of developing DCS from operational shifts in pressure between suits and lunar habitats. Although prebreathe protocols theoretically decrease the risk of DCS through denitrogenation, the consequences of an event are mission critical. Type I DCS represents the majority of hypobaric pathology and many medical organizations implement 'return-to-duty' guidelines following treatment. This case will overview a hypothetical occurrence of Type I DCS on a lunar surface EVA in an experienced astronaut and will highlight treatment, return to flying status, and mission impact. **CASE PRESENTATION:** A 55-year-old female crewmember with extensive EVA experience developed right knee pain during her first lunar surface sortie. The pain severity distracted her from mission objectives and the EVA was aborted by the supervising flight surgeon given suspicion for DCS. The crewmember was treated with an in-suit repressurization protocol and her symptoms resolved. She had no prior history of DCS and subsequent EVA for the following three days were cancelled by flight medicine due to the risk of recurrence and performance decrement. **DISCUSSION:** Exploration missions will require extensive EVA capabilities for sustained space operations, including the lunar surface and beyond. Although recurrence of treated DCS is plausible, a clear delineation of risk factors makes 'return-to-duty' difficult so mitigation continues to be the best treatment for DCS. Clinical guidelines to minimize post-treatment risk of DCS recurrence exist within the Department of Defense, commercial diving, and recreational diving sectors, however, there is a paucity of literature for cases such as this astronaut treated with hyperbaric pressures utilizing in-suit protocols.

This case report will highlight the current mission implications of DCS including unavailability of standard 41.1 psia (2.8 ATA) hyperbaric oxygen, difficulty in medical evacuation from the lunar surface, and approach to returning a crewmember back to mission EVA status.

Learning Objectives

1. The audience will gain an appreciation of risk assessment for recurrent decompression sickness in a hypothetical astronaut crewmember on a long-duration lunar surface mission.
2. The audience will learn how existing medical guidelines may apply to return-to-duty assessment for individuals operating in a hypobaric lunar habitat environment and lunar surface EVA.

[194] MARIJUANA USE WAIVERS: HIGH TIME TO CHANGE?

Barrett Campbell

U.S. Army Medical Center of Excellence, Fort Novosel, AL, United States

(Education - Case Study)

INTRODUCTION: This case report discusses two Soldiers, a 27-year-old and a 33-year-old, presenting for their installation student flight physical, both with a remote history of marijuana use. **BACKGROUND:** As the legal landscape surrounding marijuana use shifts in the United States, many individuals find themselves navigating a complex web of state and federal regulations. For military personnel with use before joining the military, this complexity is compounded by the intersection of civilian laws with military and aviation regulations. **CASE PRESENTATION:** The first Soldier, a 27-year-old, used marijuana during high school and reported this use on his three prior approved flight physicals. The second Soldier, a 33-year-old, reports use at age 18 during his college years. He also reported this use on his two prior approved flight physicals. Though neither Soldier reports ongoing use nor a history of drug abuse treatment, the past experimental use poses a challenge for their aviation aspirations based on current policy. **DISCUSSION:** The evolving legal status of marijuana in various U.S. states brings forth challenges in military and aviation contexts. While certain states have decriminalized or legalized marijuana, the Department of Defense (DoD) and its branches maintain strict policies against use by its Servicemembers. The FAA holds a clear stance that marijuana, including medicinal use, is not allowed for pilots or air traffic controllers within the last two years or with a failed drug test or history of dependence, and all drug use without prior FAA evaluation must lead to deferral of the physical by an AME to the FAA for clearance and issuance of an eligibility letter. This case exemplifies the tension between state-level marijuana legalization and federal and military regulations for use before military service. For aspiring aviators, understanding these policies is crucial. Maintaining a transparent, evidence-based, and legally sound approach mitigates various risks for these organizations. This issue underscores the need for continuous review and possible alignment of policies as societal norms and legal frameworks evolve.

Learning Objectives

1. Understand the distinctions between state-level marijuana legalization and federal/military policies on prior marijuana use.
2. Evaluate the current DoD and FAA policies in light of evolving societal norms and discuss the drivers for policy revisions.

Tuesday, 05/07/2024

2:00 PM

Grand Hall GH

[S-37]: PANEL: SAFETY CENTERS: YEAR-IN-REVIEW

Chair: Philippe Stewart

PANEL OVERVIEW: This panel presents a review of recent aerospace safety data. Representatives from military and civil aerospace organizations

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

[195] TRANSPORT CANADA: YEAR IN REVIEW

Tyler Brooks

Transport Canada, Ottawa, ON, Canada

(Education - Program/Process Review)

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

Learning Objectives

1. Understand the mission of Transport Canada Civil Aviation Medicine branch.
2. Understand key policy updates of Transport Canada Civil Aviation Medicine branch.

[196] U.S. ARMY AVIATION SAFETY: FY 2023 YEAR IN REVIEW

Luis Rivero, Sean O'Connell

U.S. Army Combat Readiness Center, Fort Novosel, AL, United States

(Education - Tutorial/Review)

INTRODUCTION: Discuss (FY) 2023 statistics and analysis for USA Class A aviation mishaps including Human Factors Analysis. **METHODS:** FY2023 data was obtained from the USA Combat Readiness Center database (ASMS2.0) for Class A thru C manned aviation mishaps and reviewed for human factors as determined by the Safety Investigation Boards. **RESULTS:** In the manned aircraft category, Army aviation experienced 67 Class A - C manned aircraft Flight mishaps in FY23. This was an increase from the 50 Class A-C Flight mishaps reported in FY22. The US Army experienced eight Class A manned aviation Flight mishaps during FY23, 100% over the four Flight mishaps reported for FY22. The accident rate for Class A Flight mishaps (per 100,000 flying hours) was 0.96 in FY23, a 92% increase from the 0.50 Class A record rate recorded in FY22. There were 14 aviation mishap fatalities in FY23 compared to 2 in FY22. **DISCUSSION:** For the fourth year in a row, Army Aviation has remained below a rate of one mishap per 100,000 flying hours and the overall five-year rate of 0.89 is the result of four years of single digit Class A Mishaps (FY20 = 6, FY21 = 8, FY22 = 8, and FY23 = 9). As a result, the Army continued to maintain a Class A mishap rate below established norms during FY23. FY23 manned Class A flight mishap rate was 0.96 per 100,000 flight hours, the fifth time in the last eight years the rate has been below the mark of 1.0 mishap per 100,000 flight hours. However, this FY had the most aviation mishap fatalities, 14, in the last 10 years and is the highest since FY08 when Army Aviation sustained 16 mishap fatalities. There were nine Class A mishaps (8 Flight; 1 Aircraft Ground) reported in FY23 with approximately 835,063 hours flown. Human error continues to be the leading cause factor in Army Class A Flight mishaps.

Learning Objectives

1. The audience will review US Army Aviation mishaps in the manned and unmanned categories.
2. The audience will be able to understand trends in US Army Aviation related to mid-level experience gap in Army Aviators which is correlated to degraded human factors capabilities in power management, operating in degraded visual environments and terrain flight skills.
3. The audience will learn about the leading causes of US Army Aviation mishaps from FY16 to FY22, which include object strikes, CFIT and hard landings, and the reason behind them.

[197] ROYAL CANADIAN AIR FORCE FLIGHT SAFETY: YEAR IN REVIEW 2023

Philippe Stewart

Canadian Armed Forces, Ottawa, ON, Canada

(Education - Program/Process Review)

BACKGROUND: The Commander of the Royal Canadian Air Force (RCAF) is appointed as the Airworthiness Authority for all aviation in the Canadian Armed Forces (CAF). The Director of Flight Safety (DFS) is appointed as the Airworthiness Investigative Authority for all flight safety occurrences with the goal of preventing accidental loss of aircraft and personnel. Contributory or causal human factors are identified using the Canadian Forces Human Factors Analysis and Classification System (CF- HFACS). Statistics and analysis from 2023 are discussed. **OVERVIEW:** Accidents and incidents from 2023 were reviewed to identify human factors which may have caused or contributed to these occurrences. **DISCUSSION:** Fatigue, culture and substances hazardous to aviation continue to be relevant hazards in the RCAF. DFS has helped to propel several risk mitigation initiatives specifically aimed these factors, including the implementation of the RCAF Fatigue Risk Management System, while facilitating the international distribution and use of SAI for accident investigations.

Learning Objectives

1. The audience will learn about the overall trends in RCAF flight occurrences in 2023.
2. The audience will learn to identify various Human Factors Analysis and Classification System (HFACS) categories that contribute to aviation incidents.

[198] NAVAL AVIATION SAFETY: 2023 YEAR IN REVIEW

Jonathan Erpenbach, George Rice, Jefferson Grubb, Jarrett Moore, Nicola Robinson

U.S. Navy, Naval Safety Command, Norfolk, VA, United States

(Education - Program/Process Review)

BACKGROUND: The Naval Safety Command analyzes Navy and Marine Corps aviation safety investigation reports in order to identify mishap causal factors and recommend corrective actions. **OVERVIEW:** All Class A flight mishaps involving U.S. Navy and Marine Corps aircraft during fiscal year 2023 (FY 2023) were reviewed using the Human Factors Analysis and Classification System (HFACS). During FY 2023, there were multiple Class A flight mishaps in the U.S. Navy and U.S. Marine Corps. A review of Class A flight mishaps over the past ten years demonstrated that human factors were the predominant causal factor. The Naval Safety Command team will also present a review of current physiological episodes and events in Naval Aviation. **DISCUSSION:** HFACS can be a useful tool in safety investigation analysis and assist in identifying mitigation strategies to prevent future mishaps. Evolving capabilities and understanding regarding physiological episodes and events are enabling technological improvements, better training, and impactful research to further reduce occurrences, risks, and impacts to mission.

Learning Objectives

1. Review the overall trend in U.S. Navy and Marine Corps flight mishaps and the most common human factors identified as causal factors.
2. Review the trends in Naval Aviation mishap HFACS causal factors over the last decade.
3. Become familiar with emerging topics of discussion at the Naval Safety Command related to aviation, including physiologic events.

[199] AIR FORCE AVIATION AND SPACE SAFETY: 2023 YEAR IN REVIEW

Kevin Alford, Andrew Metelko, Mark Noakes
U.S. Air Force, Albuquerque, NM, United States

(Education - Program/Process Review)

BACKGROUND: The United States Air Force Safety Center's Human Performance and medical experts support commanders and safety professionals Air Force wide by applying human factors (HF) expertise to identify, anticipate, analyze, and mitigate human factors risk in Air Force operations while advancing safety culture. **OVERVIEW:** All Class A & B mishaps, manned/unmanned aviation mishaps were analyzed to assess trends in human factors across event types to include physiological events using the Air Force Safety Automated System database of mishap reports. Mishap rates were stable from preceding years with notable patterns of HF identified during subset analyses. Implementation of the Department of Defense Human Factors Analysis and Classification System (HFACS) version 8.0 presents challenges in comparing HFACS over time. **DISCUSSION:** Human factors contribute significantly to aviation mishaps representing a pivotal area for improvement in the goal to reduce mishaps. Results of data analysis on mishap trends and characteristic among varying event types are presented and highlight opportunities for interventions to improve aviation safety.

Learning Objectives

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

Tuesday, 05/07/2024
Grand Hall I

2:00 PM

[S-38]: SLIDES: ASTRONAUT MEDICAL OPERATIONS

Chair: Benjamin Johansen
Co-Chair: Jennifer Fogarty

[200] HUMAN AND ENVIRONMENTAL RESEARCH MATRIX FOR EXPLORATION OF SPACE (HERMES) PROJECT

Jimmy Wu, James Hury, Jennifer Fogarty, Rihana Bokhari,
Emmanuel Urquieta, Dorit Donoviel
Baylor College of Medicine, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: The emerging commercial spaceflight industry has several companies all building an assortment of spaceflight vehicles, space stations, and habitats each with different levels of health care and

capabilities to provide the spaceflight participants (SFP) a pleasurable spaceflight experience. The Human and Environmental Research Matrix for Exploration of Space (HERMES) project aims to standardize and manage the biomedical and environmental data needed to maintain the human health and performance of SFP as they venture through their spaceflight journey. **OVERVIEW:** HERMES is a semi-autonomous, vehicle agnostic, data management infrastructure with capability to 1) seamlessly aggregate spaceflight related biomedical, research, operational, and environmental data, 2) store said data in an efficient manner that allows for 3) access and distribution of the data to human users, to algorithmic (AI/ML) users, and to downstream spacecraft that also have HERMES infrastructure. This project addresses a commercial spaceflight landscape where space vehicles and destinations are built and operated by various commercial entities making it challenging to establish a standardized way for data to be aggregated, stored, and distributed. **DISCUSSION:** HERMES allows for a paradigm shift in how medical, research, and environmental data is managed across disparate space vehicles and destinations. SFP health status, research, and environmental exposure data collection, storage, and distribution are standardized making the infrastructure flexible enough to be ubiquitously deployed regardless of the spacecraft, biomedical data sources, and data analysis users. This enables a novel data management model where a SFP's data can follow the SFP as they continue their spaceflight journey allowing subsequent spaceflight operators insight into the SFP's health, performance, and exposure history. HERMES can support any organization that operates multiple non-standardized transportation vehicles and remote destinations such as NASA's Artemis Program and the military where collection, storage, and analysis of their personnel's data is critical to maintenance of health and performance. This research is supported by the Translational Research Institute for Space Health (TRISH), funded under NASA Cooperative Agreement NNX16AO69A.

Learning Objectives

1. The audience will learn about the challenges in collecting biomedical, operational, and environmental data on commercial spaceflight missions.
2. The audience will learn about common and novel data management approaches that can be applied to human health and performance on commercial spaceflight missions.

[201] HAZARDS VULNERABILITY ANALYSIS FOR COMMERCIAL SUBORBITAL FLIGHT

Tovy Kamine¹, Luke Apisa², Dana Levin³

¹UMass Chan Medical School - Baystate, Springfield, MA, United States;

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(Education - Program/Process Review)

BACKGROUND: As commercial suborbital spaceflight increases in popularity and decreases in cost, the need for readiness to respond to medical emergencies and mass casualty events increases. Many of the launch facilities are in remote areas far from definitive care and having skilled responders on site can save money and time in costly evacuations as well as lives in extreme cases. Prior work described hypothetical guidelines in 2012 but the industry has matured substantially in the more than decade since and it is important to revisit the needs in light of the no longer hypothetical flights. This study reviews the hazards, training, and response needs for providers supporting suborbital space activities. **DESCRIPTION:** This study uses standard event medicine, disaster medicine, and emergency medicine techniques to guide the creation of an emergency operations plan that encompasses an all-hazards model. A hazards vulnerability analysis (HVA) was created for a commercial suborbital spaceflight mission encompassing prelaunch procedures, launch, landing, and post flight procedures. Specific hazards included in the analysis included on board and on ground temperature extremes; chemical exposure, communications failure, earthquake, explosion, fire, flood, inclement weather, mass casualty incident-Hazmat; mass casualty

incident—trauma, picketing, tornado, workplace violence, active shooter. In addition, common injury and illnesses during commercial, aerobatic, and space flights were reviewed and considered to scope emergency readiness and training needs. **DISCUSSION:** The use of emergency, event, and disaster medicine planning techniques is useful to developing response plans and scoping the training needs for those responding to suborbital spaceflight incidents.

Learning Objectives

1. The audience will learn about how to create an emergency operations plan based on a hazards vulnerability analysis relevant to commercial space flight operations
2. The audience will learn how a hazards vulnerability analysis can guide discussions about safety of commercial spaceflight launch and landing operations.

[202] NASA-KENNEDY SPACE CENTER (KSC) BIOMEDICAL SUPPORT OF ARTEMIS I

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(Education - Program/Process Review)

BACKGROUND: NASA is preparing to return humankind to the moon in a program called Artemis. The first step in this journey was the Artemis I uncrewed flight around the moon at the end of 2022. This presentation will cover the multiple aspects of preparing and supporting the first Artemis mission provided by NASA Kennedy Space Center biomedical personnel.

OVERVIEW: KSC civil servant and contractor medical, environmental health, biomedical engineers, and others provided support to Artemis I. Support consisted of Emergency Medical Services/Triage, Mine Resistant Ambush Protected Vehicle (MRAP) outfitting and training, and Launch Control Center Firing Room Console Command and Control all in place to cover potential ground crew emergencies occurring within the Artemis I active Blast Danger Area near the launch pad. Biomedical personnel supported all Artemis I readiness reviews, wet dress rehearsals, launch attempts, and the successful launch of Artemis I on November 16, 2022. Medical screening for all Orion capsule Landing and Recovery personnel and landing simulation at-sea tests were provided. Direct medical support preparations on the Orion Rapid Response Team as team physician for worldwide medical care was also provided. Key planning support also included as NASA Health and Medical Technical Authority (HMTA) delegate overseeing all Artemis Requirements, Design, Construction, Testing and Operations Readiness Reviews for Orion Ground Processing, Vehicle Stacking and Integration, Rollout, Launch, Landing and Recovery, and Deservicing activities. NASA-KSC personnel worked alongside Johnson Space Center and NASA Headquarters Health and Medical personnel in various efforts to ensure all aspects and lessons of Artemis I benefit the safety and human-rating success for Artemis II and subsequent crewed missions.

DISCUSSION: The multiple aspects of preparation and biomedical support at the NASA-KSC of the historic Artemis I mission directly enhanced and prepared NASA to support future crewed Artemis missions.

Learning Objectives

1. The audience will learn about NASA's new program to return to the moon.
2. The audience will understand the multiple biomedical aspects that were involved in support of Artemis I.
3. The audience will appreciate the importance of experience gained in Artemis I to be applied toward future crewed Artemis missions.

[203] PRESERVED RED BLOOD CELLS FOR TRANSFUSION THERAPY IN REDUCED GRAVITY

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(Original Research)

INTRODUCTION: Spaceflight-induced anemia or traumatic blood loss can threaten astronaut health and will require blood transfusion for treatment on an exploration spaceflight. Until mitigation countermeasures are created, there is a critical need for a red blood cell transfusion method compatible with spaceflight. The limitations of current whole blood storage methods (regulated refrigeration for no more than 42 days) are unacceptable for spaceflight missions. A new technology that preserves red blood cells by optimized dehydration (dRBC) for up to four years at ambient cabin conditions provides an emerging option.

METHODS: Using compounds upregulated in desiccation-tolerant organisms (anhydrobiotes) and automation of biomedical processes, dehydration techniques for RBCs combined with flow-through ultra-sound induced loading of lyoprotectants have resulted in the successful preservation of dRBCs for more than four years. Flight performance of dRBCs was evaluated during 0-g periods of parabolic flight to assess rehydration and cell recovery as well as blood gases. **RESULTS:** Successful rehydration and recovery of dRBCs (>70%) comparable to 1-g values was demonstrated in parabolic flight with in-flight pO₂ ≥ 150 mm Hg. Effective simulation of dRBC infusion was also demonstrated in parabolic flight. **DISCUSSION:** The dRBC-based transfusable units are thermally stable, easily stored, have significantly extended shelf-life compared to current blood preservation protocols, rehydrate rapidly in reduced gravity, are lightweight, and use a conventional blood infusion set. We anticipate that crews will launch from Earth with dual-chamber bags containing compatible dRBCs and rehydration solution, and COTS transfusion sets packed in medical supply kits for immediate use. The Crew Medical Officer would manually rehydrate the dRBC and IV transfuse the crew member using a standard transfusion set with pressure bag augmentation. These favorable characteristics of dRBCs support critical care capabilities for exploration space missions. Further evaluation of dRBC rehydration in microgravity will occur during a suborbital flight in 2025. Four units will be automatically rehydrated using a mechanical compression system while optical sensors determine oxyhemoglobin and methemoglobin levels. Rehydrated RBC morphology (after in-flight fixation) will be assessed post-flight by SEM. [NASA-80NSSC18K1664, DOD W81XWH-20-1-0866, NSF PFI-1827521, NASA 80NSSC23K0855]

Learning Objectives

1. Understand the difference between the current practice to preserve red blood cells (packed cells) for transfusion therapy and the preservation of dehydrated red blood cells.
2. Understand the difference between the current useful period and methods for storage of red blood cells and the useful period and methods for storage for dehydrated red blood cells.
3. Understand the difference between the current preparation methods for the transfusion of currently used red blood cells and the preparation methods for the transfusion of dehydrated red blood cells.

[204] THE MORTALITY OF RUSSIAN SPACE EXPLORERS, 1960-2021

Kristina Betts¹, Igor Bukhtiyarov¹, Igor Ushakov², Yuri Voronkov³, Maksim Kharlamov⁴, Anatoly Zhernavkov⁴

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WITHDRAWN

Tuesday, 05/07/2024
Grand Suites 2 & 3

2:00 PM

[S-39]: POSTERS: SPACE FOR POSTERS

Chair: Thomas L. Powell

Co-Chair: Chuck Reese

[205] SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME: ASSOCIATIONS AND RELATIONSHIPS

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(Original Research)

INTRODUCTION: Spaceflight Associated Neuro-ocular Syndrome (SANS) is a condition that negatively impacts crew eyesight and ocular health and is defined by four primary ocular signs: optic disc edema, chorioretinal folds, hyperopic refractive error shift, and globe flattening. Exact pathogenesis and relationships between signs remain poorly understood. **METHODS:** Data were collected from U.S. astronauts utilizing diagnostic modalities at pre-, in-, and post-flight time points. This dataset was assessed for associations and relationships across a variety of variables including disc edema, chorioretinal folds, MRI/US globe flattening, refractive error, sex, laterality, and prevalence of SANS using Fisher's exact t-test. **RESULTS:** Global analysis determined that 58% of subjects (n=260) demonstrated signs of SANS. From the subset diagnosed with SANS, cycloplegic refractive error was significantly associated with optic disc edema and chorioretinal folds ($p = 0.001$ and $p = 0.0029$, respectively). Males were more affected than females ($p = 0.005$). The association of disc edema and chorioretinal folds was statistically significant ($p < 0.0001$). There was no difference in prevalence of SANS regarding eye laterality ($p = 1.00$), regardless of sex ($M(n=409 \text{ eyes})/F(n=90 \text{ eyes})$ $p = 0.869$ vs 0.766 respectively). **DISCUSSION:** SANS signs showed a variable distribution. Some individuals had no signs, while others displayed multiple. Given limitations, it is difficult to ascertain whether this is due to differences in sex seen prior to missions or due to changes during missions, as females were noted to have statistically significantly less total number of flights and flight mission time than males.

Learning Objectives

1. The audience will be able to describe current Spaceflight Associated Neuro-ocular Syndrome (SANS) findings, significance, and counter-measures.
2. The audience will be able identify and appreciate relationships and associations between individual variables related to spaceflight associated neuro-ocular syndrome, with an understanding that there are significant difficulties and limitations when performing spaceflight related ocular measurements and analysis.

[206] BRAIN BIOMARKERS TO UNDERSTAND SPACEFLIGHT IMPACT

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(Education - Tutorial/Review)

INTRODUCTION: The brain undergoes multiple changes in spaceflight. Cephalad fluid shifts occur with venous congestion and cerebrospinal fluid (CSF) redistribution. The brain shifts upward and there is vertex crowding with narrowing of the central sulcus. Microgravity, in combination with continuous space radiation and increased carbon dioxide levels on the International Space Station (ISS), could also lead to disruption of the blood-brain barrier (BBB) and subsequent increased permeability and inflammation. Changes in gray and white matter volumes and periventricular white matter hyperintensities have been seen on imaging studies of previous crewmembers who completed long duration spaceflight missions. The long-term effects on the brain remain unknown, but could include a possible increased risk of cognitive decline or dementia. Out of 371 total NASA astronauts, seven individuals who experienced spaceflight were diagnosed with neurodegenerative dementia between 1994 and 2019, including five with Parkinson's disease, one with Alzheimer's disease, and one with frontotemporal dementia. **TOPIC:** A recent pilot study of five cosmonauts exposed to the long-duration spaceflight environment measured blood-based biomarkers commonly associated with brain pathology including neurofilament light chain (NFL), glial fibrillary acidic protein (GFAP), total tau protein, and two amyloid-beta proteins (A β 40 and A β 42), demonstrating possible deleterious effects of the space environment.

APPLICATION: A research protocol for monitoring of blood biomarkers in astronauts has been developed to provide more comprehensive data of selected biomarkers before and after spaceflight missions. The voluntary protocol will be administered initially with the astronaut selection medical exam to establish a baseline. After identification for a specific spaceflight mission, further biomarker testing of the astronaut will be accomplished at intervals prior to launch and after landing until reaching a plateau. Assessment of blood biomarkers will resume when the astronaut is identified for another spaceflight mission. Upon retirement, blood biomarkers will be checked every five years as part of surveillance exams. If biomarkers are found to be elevated or have an increasing trend, a referral to a neurodegenerative disorder specialist will be placed for further workup.

Learning Objectives

1. Understand the mechanism of potential deleterious effects of spaceflight on the brain.
2. Determine if blood-based biomarkers can be used to monitor brain injury and/or the development of future neurodegenerative disease.

[207] FAST ULTRASOUND USE IN SPACE – A STUDY WITH MEDICALLY INEXPERIENCED INDIVIDUALS

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(Original Research)

INTRODUCTION: Focused assessment with sonography in trauma (FAST) is a quick procedure of high accuracy that can be used in emergency medicine diagnostics. For other medical measurements (blood pressure, ECG, oxygen saturation) it was shown that individuals with no experience can conduct these measurements by following in-built instructions and without any relevant difference to medical personnel in duration and quality. However, the quality of FAST outcomes is highly dependent on the proficiency of the operator. Most astronauts are neither medical doctors nor ultrasound professionals, receiving only a certain degree of medical training before missions. Because of that, it is important to investigate and develop strategies to support astronauts during medical procedures, especially in the perspective of deep space exploration. **METHODS:** Participants (35 men and 4 women, median age 31 years [min-max: 18-58 years]) with only basic first aid training and

without ultrasound experience were instructed to conduct a FAST (including right and left upper quadrants, and pelvic scans) on a simulated patient after an accidental abdominal blunt-force trauma. Participants were instructed to follow in-built instructions provided by the vital signs monitor TEMPUS Pro and to evaluate the workload with the NASA-TLX. The ultrasound video recordings were examined by physicians with ultrasound experience, evaluating if the participants were able to conduct an acceptable FAST. **RESULTS:** The NASA-TLX showed a low median total score (6.3 [3-15]) with no significant differences in the sub-scales: mental (9.0 [1-18]), physical (5.0 [1-13]) and temporal demand (8.0 [1-19]), performance (7.0 [1-17]), effort 7.0 [2-18]), and frustration (5.0 [1-17]). Although the reported workload was low, participants were not able to conduct an acceptable FAST ultrasound with a valid examination of all three compartments. **DISCUSSION:** In contrast to other medical procedures that can also be used by people with little medical experience with an in-built instruction, our study shows that this cannot be transferred to FAST. For future deep space exploration missions, it will be necessary to improve the in-built instructions and to train astronauts to be able to conduct an acceptable FAST.

Learning Objectives

1. The participants will learn how automatically in-built instructions in medical systems can support deep space exploration missions.
2. The participants can understand that further training is necessary for inexperienced individuals conducting FAST ultrasound diagnostics, before sufficient results are achievable.

[208] VITAMIN D LEVELS IN ISRAELI AIRCREW MEMBERS

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(Original Research)

INTRODUCTION: Vitamin D is crucial for calcium homeostasis, bone health, and various biological processes. There is no consensus regarding vitamin D sufficiency levels. Various scientific societies suggest different thresholds with accepted values of 25(OH)D being 30, 20 and 12 ng/mL. The aim of this study was to establish normal vitamin D values for the Israeli Air Force (IAF) air personnel. **METHODS:** Data from medical records of aircrew who underwent an annual routine health checkup between 2020 and 2022 were analyzed. The subjects were examined at the IAF Aeromedical Center. All subjects were healthy and had no clinical signs of vitamin D deficiency. This study was approved by the Institutional Review Board. **RESULTS:** Records of 358 air personnel were analyzed. Mean age was 31.1 ± 11.4 years (range 18-60), mean BMI 24.43 ± 2.82 (range 17.6 – 34.4) with a male predominance (93.6%). Levels of 25(OH)D were normally distributed around a mean value of 27.14 ± 7.07 ng/mL (range 6.4-48.4 ng/mL), median of 31.25 ng/mL and interquartile range of 8.8 ng/mL. Vitamin D levels had a negative weak correlation with age, with a Pearson's correlation coefficient $\rho = -0.22$ (P value < 0.001). There was no statistical significant gender difference. **DISCUSSION:** With sufficiency levels at 30, 20, and 12 ng/mL, the percentage of subjects with sufficient vitamin D levels would be: 65%, 86%, and 99% respectively. Given our population's health, youth, and sunny country residence, we argue the vast majority should have sufficient values. With a normal distribution around a mean of 27.14 ng/mL, 95% (2SD) of our population falls between the values of 13.00 and 41.28 ng/mL. Our findings align with previous studies, suggesting that a threshold of 30 ng/mL is possibly excessive for the Israeli population.

Learning Objectives

1. Mean vitamin D [25(OH)D] level for IAF air personnel is 27.14 ng/mL. Sufficiency levels fall between 13 and 41.28 ng/mL.
2. Previous values of 25(OH)D (40-100 ng/mL) used in the IAF appear to be too high.

[209] INCREASING NEED OF ORTHOPEDISTS FOR ASTRONAUTS IN SPACE MEDICINE, DEFINING FUTURE STANDARDS, AND REVIEW OF PERI-FLIGHT MUSCULOSKELETAL INJURIES

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(Original Research)

INTRODUCTION: The space sector is growing fast. Its value is expected to increase from \$447 billion in 2022 to \$2.7 trillion by 2040. This encompasses the increase of start-ups, active satellites, launches per year, space hotels, private funding, and astro-tourism. As the demand for astronauts and astro-civilians grows, so will musculoskeletal (MSK) injuries during pre-flight training, in-flight, and post-flight. This increase requires a greater demand of orthopedists in space medicine. The role of orthopedists in space medicine is sparsely reported in literature and standards of care for astro-civilians are not well established. This study establishes the current prevalence of peri-flight MSK injuries in astronauts and discusses standards of care for astro-civilians. **METHODS:** A systematic review using PubMed, MEDLINE, and NASA Technical Report Server databases was performed to identify original research containing MSK injuries in astronauts. The number of peri-flight injuries and their bodily locations documented were used to determine their prevalence from 1959 to 2023. **RESULTS:** The prevalence in 2388 documented injuries of pre-flight is 46.5%, in-flight is 37.0%, and post-flight is 16.5%. The prevalence in 2081 documented injury locations of the upper extremity is 32.4%, shoulder is 31.4%, back is 26.4%, lower extremity is 5.5%, and neck is 2.3%. **DISCUSSION:** Common peri-flight injuries involve the shoulder, back, and hand. Muscle atrophy decreases at rates between 9-11% during 17 day space missions. Astronauts lose up to 1 to 2.4% bone mineral density in the hip and lumbar spine per month and have an incidence rate of 4.3 times for herniated discs compared to individuals who have not undergone spaceflight. It is critical to consider MSK injuries for the growing space sector. Space tourism's estimated market value is \$23 billion by 2030. As public interest grows, costs related to space are expected to decrease such as space stations from \$110 to \$5 billion and heavy launches from \$1,500 to \$100 per kilogram. Private companies want 5 million space tourists in 2030 and to make space travel commercially available. Decreased costs increase the accessibility to space and consequently the risk of MSK injuries. Space adaptation back pain has an occurrence rate of 52% in astronauts. Millions could develop space adaptation back pain. Rising MSK injuries will increase the demand for orthopedists in space medicine and standards of care need to be established.

Learning Objectives

1. The audience will learn about pre-flight, in-flight, and post-flight musculoskeletal injuries obtained by astronauts and the most common types of injuries.
2. The audience will learn about the prevalence of astronaut peri-flight musculoskeletal injuries and their bodily locations.
3. The audience will learn about the goals of the space sector and its increasing growth, astro-civilians and astro-tourism, and a need for developing new standards of care in space medicine due to a likely increase in astronautic musculoskeletal injuries.

[210] RADIATION SHIELDING: THE PAST, THE PRESENT, AND THE FUTURE

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(Education - Program/Process Review)

BACKGROUND: With NASA's Artemis program underway and commercial spaceflight growing, astronauts will live in space for longer

than ever outside the protective shell of the Earth's geomagnetic field and atmosphere. During extended spaceflight, EVAs, and missions to live on the lunar and Martian surfaces, astronauts have the potential for long-term exposure to the harmful effects of radiation in the form of solar particle events (SPEs) and galactic cosmic rays (GCRs). With current shielding materials, it is estimated that a mission to Mars would result in an effective radiation dose of approximately double the recommended lifetime radiation exposure for astronauts (600mSv). This article will review existing literature on past, current, and near-future shielding technologies, which can be broadly divided into passive and active shielding. **OVERVIEW:** For passive shielding materials, as the thickness is increased, there is a resulting decrease in the effective dose for many traditional types of radiation. However, the high mass and energy (HZE) radiation of GCRs can paradoxically increase effective dose through collisions with shielding materials and scattering of secondary neutrons and other forms of radiation from the shielding materials. This article will examine literature classifying the properties of shielding materials, including their stopping power, total nuclear fragmentation cross-section, and ability to absorb neutron radiation. By combining various materials, it might be possible to synergize the shielding properties and produce superior shielding. For active shielding technologies, electromagnetism is employed to provide shielding akin to Earth's geomagnetic field. While technical challenges for implementation exist, this represents an exciting area of study, with early tests showing significant reductions in dose equivalents of radiation. Hybrid approaches, which combine active and passive shielding technologies to further reduce the equivalent radiation dose, will also be examined. **DISCUSSION:** Newer and more effective shielding strategies are essential for the success of long-term spaceflight and exploration. Current methods in use limit exploration; fortunately, near-future implementation of new passive shielding materials and effective active shielding will greatly reduce the risk, pushing the boundary of exploration even further. This work is relevant to the current climate of Mars exploration and commercial space exploration.

Learning Objectives

1. The reader will be able to effectively understand current and future shielding technologies in place to mitigate Space radiation exposure.
2. The reader will be able to understand why shielding is essential to further human exploration and key to the success of a mars mission/ commercial space/longterm space habitation.
3. The reader will be able to understand the challenges we face today in implementing future shielding technology and work being done to overcome it.

[211] EXTREME REDUCTIONS IN BODY MASS INDEX AS AN ANALOG FOR WEIGHTLESSNESS TO EXAMINE VOLUMETRIC CHANGES IN THE BRAIN

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(Original Research)

INTRODUCTION: MRI measurements from spaceflight participants after extended weightlessness show significant enlargement of cerebral ventricles, with some studies demonstrating reduced total brain volume. Although modeling the complete loss of body weight is not possible on Earth, bariatric surgery produces a rapid reduction in body weight that may serve as a partial analog. This study investigated whether extreme weight loss leads to changes in brain volumes similar to those seen after spaceflight. **METHODS:** Data were used from a prior study which collected MR scans on bariatric surgery patients and non-treated controls of comparable obesity. All subjects were right-handed, nonsmokers, otherwise healthy, and on no medications affecting bodyweight. This study selected six subjects with a BMI reduction ³ 10 and six random control subjects with no BMI change. Scans were acquired for each subject preoperatively, and again four months after surgery. Total brain and

ventricular volumes were then segmented using ITK-SNAP, and analyzed with a rmANOVA using weight loss (WL) and no weight loss (NWL) as the grouping variable. **RESULTS:** Total brain volume decreased significantly in both groups (WL: 8.5×10^3 to 7.9×10^3 mm³, NWL: 8.5×10^3 to 8.3×10^3 mm³) (ANOVA, $p=0.005$), however total volume decreased significantly more in the WL group (8.1%) than in the NWL group (1.6%) (ANOVA, $p=0.04$). Ventricular volume increased in the WL group and decreased in the NWL group, but this interaction was not significant (ANOVA, $p=0.33$). When the ventricular volume changes were normalized to total brain volume, there was a trend toward a significant interaction (ANOVA, $p=0.09$). **DISCUSSION:** Total brain volume decreased significantly more after bariatric surgery among WL subjects compared to NWL subjects. The ventricular volume/brain volume ratio also trended toward being greater in the WL group. This provides evidence that significant weight loss is associated with decreased cerebral volume. Although we initially hypothesized this may be due to loss of body weight causing changes in tissue pressures or motor cortex neglect, it could also be due purely to a loss of body mass as astronauts typically lose body mass in space. These data suggest a need for further study on how to use weight loss as an analog for weightlessness.

Learning Objectives

1. The audience will understand the currently observed correlations between weightlessness in spaceflight and alterations in human brain volume.
2. The audience will be able to understand the utility of weight loss on Earth as an analog for weightlessness by which to study the effects of spaceflight on the human brain.

[212] OSTEOPATHIC MANIPULATIVE THERAPY "MONEY" TECHNIQUES FOR MANAGING COMMON MUSCULOSKELETAL CONDITIONS ON THE INTERNATIONAL SPACE STATION

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(Education - Program/Process Review)

BACKGROUND: Spaceflight associated musculoskeletal (MSK) complaints such as hand and shoulder overuse, shoulder impingement from extravehicular activity, and space associated back pain are well established complications of crewed spaceflight. MSK issues can affect crew performance and have the potential to impact operations. Osteopathic Manipulative Therapy (OMT) is set of manual medicine techniques which can be used to address MSK pain, compressive neuropathies, and many other complaints. MSK cases during spaceflight have shown improvement with OMT. **OVERVIEW:** For this project researchers sought to develop criteria and guiding principles for the creation of OMT techniques for use in microgravity. The most common MSK complaints for the upper body were selected as the focus of this project. Due to changes withing intervertebral discs in microgravity, High Velocity Low Amplitude (HVLA) techniques were excluded. Considerations for technique design included the modification of standard treatment mechanics due to microgravity, lack of specialized equipment, and development of appropriate techniques to be performed by astronauts not experienced providers. Additional challenges including the inability to utilize body weight as potential force and limited anchoring points within modules. Techniques also had to avoid imparting any unusual stresses to the craft. Direct, indirect, self and partner techniques were developed. Written and video instructional material were developed for use by astronauts in-flight and flight surgeons on console. Future considerations for OMT onboard the ISS include treatments for the lumbar spine, lower extremities, as well as non-MSK dysfunction including urinary retention, gut motility, and

proprioception. **DISCUSSION:** OMT is a therapeutic option for a variety of MSK and non-MSK complaints. It is ideal for the resource constrained environment of the ISS and future long term space missions. Benefits include minimal time required for treatment and relatively few contraindications or side effects. No special equipment is required and OMT as a treatment modality could reduce utilization of medical consumables while supporting continued operations. This project has potential impact on international space operations, both government sponsored and civilian.

Learning Objectives

1. The audience will understand some of the key considerations in developing OMT techniques for use in microgravity.
2. The audience will understand the benefits of non-pharmacological therapy in long duration space flight.

[213] A USE OF A SUPEROXIDE DISMUTASE MIMETIC TO PROTECT JOINT SOFT-TISSUE DURING SHORT AND LONG DURATION SPACEFLIGHT

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(Original Research)

INTRODUCTION: Reduced weight-bearing in microgravity damages musculoskeletal tissues, as previously identified in ground-based tail suspension models. Cartilage and meniscal degradation that occurred during spaceflight aboard the International Space Station for the Rodent Research-9 mission occurred with reduced antioxidant defenses and increased oxidative stress biomarkers, which indexes arthritic responses. We hypothesize that a superoxide dismutase mimetic, MnTnBuOE-2-PyP5+, can act as a countermeasure against microgravity induced joint damage during short and long duration spaceflight. **METHODS:** N=47 10-week-old C57BL/6 male mice were studied; n=23 were launched to the ISS for 35 days as part of the RR-18 mission (Launch Dec 2021). N=10 received either BuOE (n=5 FLIGHT35+BuOE, 1mg/kg/weekly) or saline vehicle (n=5, FLIGHT35) and returned live after 35d. N=13 remained aboard ISS until 75d for on-orbit sacrifice (n=6 FLIGHT75+BuOE; n=7 FLIGHT75). Both arms included ground controls (n=10 GC35; n=14 GC75). Intact knee joints, femoral heads, and tibiae were isolated from right hindlimbs for micro-CT analysis. Data was analyzed using 2-way analysis of variance (ANOVA). Animal use, study design, and ethics were approved by appropriate IACUCs. **RESULTS:** Meniscal volume was lower after 35d spaceflight vs control (-9.4% vs GC35); antioxidant administration attenuated this loss (FLIGHT35+BuOE -1.2% vs GC35). Tibial articular cartilage thickness was similar between FLIGHT35 and GC35, BuOE treatment alone increased thickness (+12.8% FLIGHT35+BuOE vs FLIGHT35, +16.6% GC35+BuOE vs GC35). In contrast, meniscal volume was unchanged from controls by 75d, regardless of antioxidant treatment. However, tibial articulate cartilage thinning occurred in FLIGHT75 vs GC75 (-11.6%), with BuOE failing to preserve the articular cartilage (-14.4% FLIGHT75+BuOE vs GC75). **DISCUSSION:** Treatment with BuOE protects against space flight induced meniscal degradation during short duration (35d) missions and promoted articular cartilage thickness in all groups after 35d. However, while meniscal degradation was similar between flight and ground control groups after 75d in orbit, articular cartilage thinning was observed in flight mice that was not prevented by the antioxidant countermeasure. Given the small sample size, further investigations are needed to understand the mechanism of BuOE treatment in mitigating soft-tissue joint damage during both short and long-term spaceflight.

Learning Objectives

1. The audience will learn about the deleterious effects of microgravity on joint health in relation to the pathophysiology of arthritis.

2. The audience will learn about pharmacologic strategies in mitigating microgravity induced joint degradation with applications both terrestrially and for long duration missions.

[214] VENOCONSTRICTIVE THIGH CUFFS: A SAFE AND EFFECTIVE COUNTERMEASURE TO REVERSE THE HEADWARD FLUID SHIFT

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(Original Research)

INTRODUCTION: The Braslet is a custom-built venoconstrictive thigh cuff (VTC) used by crewmembers flying on the Soyuz spacecraft to reduce symptoms associated with the headward fluid shift during the adjustment to spaceflight. However, crew traveling to the International Space Station (ISS) on commercial vehicles do not have access to VTCs. NASA's Cardiovascular and Vision Lab at Johnson Space Center, in collaboration with Clemson University, has developed VTCs similar in form and function to the Braslet but in small to extra-large size ranges with the ability to measure the applied pressure. The purpose of this project was to develop sizing protocols and document thigh circumference ranges for each size VTC, characterize the VTC pressure at which femoral venous blood flow is restored, and assess the magnitude of fluid shift reversal.

METHODS: Thigh circumference was measured at VTC placement in 21 healthy participants (13M, 8F), and VTC sizing was determined based on ability to achieve the target pressure of 50 mmHg. Doppler ultrasound was used to assess femoral venous flow with and without VTC use and with plantarflexion across decreasing pressure intervals. We also assessed effectiveness of daily VTC use for six hours to reverse the headward fluid shift during a head-down tilt bed rest (HDTBR) study. This project was approved for human subjects research by NASA JSC's IRB. **RESULTS:** Thigh circumference at VTC placement for small and medium sizes were 57.6±2.5 and 64.0±3.7 cm, respectively. Most participants restored venous flow at 10 mmHg, and all restored flow during plantarflexion at 50 mmHg. Use of the VTC increased thigh circumference, reduced cardiac output, and decreased IJV area; these findings did not occur in control subjects who did not use VTCs. **DISCUSSION:** While further testing is needed to evaluate larger VTC size ranges, additional work is needed to understand if loss of leg volume during spaceflight will necessitate different sizing. Additionally, universal return of flow upon plantarflexion highlights that venous blood flow is not completely occluded, and would be expected to intermittently flow past the VTC as crew conduct normal activities throughout the ISS, thus minimizing risks of potential clot formation. These data suggest the VTCs are safe to use for up to six hours, are effective at trapping fluid in the legs and reducing the headward fluid shift, and should be considered as a countermeasure for use during spaceflight.

Learning Objectives

1. The audience will be able to explain what venoconstrictive thigh cuffs are and what their intended purpose is.
2. The audience will be able to describe outcomes documenting the effectiveness of VTCs as a countermeasure to the headward fluid shift.

[215] CAFFEINE CONSUMPTION ABOARD THE INTERNATIONAL SPACE STATION

Zachary Glaros¹, Rachel Jansen¹, Alisa Braun², Sara Zwart¹, Scott Smith¹, Erin Flynn-Evans¹

¹NASA, Mountain View, United States; ²San Jose State University, San Jose, CA, United States

(Original Research)

INTRODUCTION: Caffeine is the most widely used performance-enhancing drug on Earth and astronaut crews have access to caffeine pills and liquid coffee. While caffeine is a potent countermeasure to improve alertness and performance, it also interferes with sleep. This leads to performance deficits on the following day, driving a cycle of caffeine use to counter the effects of caffeine-induced sleep disruption. Caffeine availability may be limited during future Artemis and Mars missions. As a result of mission constraints, it is critical that we 1) determine the prevalence of caffeine use among crews, 2) characterize the impact of caffeine on performance, and 3) characterize the impact of caffeine on sleep. Our aim in this study is to describe the use of caffeine aboard the ISS and begin to look at the relationship between caffeine use and sleep outcomes. **METHODS:** Data consisted of calculated amounts of daily caffeine consumed based on daily food and beverage intake for 25 astronauts on the International Space Station. On average, crew collected dietary data for 179.68 days inflight (SD = 68.61). **RESULTS:** Across all crew, individuals consumed an average of 96.99 mg (SD = 92.29 mg) of caffeine per day. All astronauts in this study consumed caffeine (25/25) at some point during spaceflight, though the frequency, amounts, and regularity differed across crewmembers. Approximately a quarter of crewmembers were regular caffeine consumers (6/25), i.e., they ingested at least 90 mg (equivalent to one cup of coffee) on 90% of inflight days. **DISCUSSION:** Our findings demonstrate that caffeine is regularly consumed by crewmembers, though consumption patterns vary across individuals. Future analyses will involve combining these data with sleep outcomes to determine the relationships between caffeine consumption and sleep. This information will provide us with an understanding of how caffeine is being used inflight to help guide countermeasure use in future missions.

Learning Objectives

1. This research shows that caffeine is regularly used by astronauts aboard the ISS.
2. This research shows that more data regarding caffeine consumption is needed.

[216] HEMORRHAGE CONTROL METHODS FOR SPACE FLIGHT: LESSONS FROM RURAL TRAUMA CARE

Jace Bradshaw, Imelda Muller, Mark Shelhamer
Johns Hopkins University, Baltimore, MD, United States

WITHDRAWN

Tuesday, 05/07/2024
Grand Ballroom CD South, EF

4:00 PM

[S-40]: PANEL: A MODEL FOR A DEPARTMENT OF MEDICAL OPERATIONS AT A COMMERCIAL SPACE COMPANY

Sponsored by Axiom Space Inc

Chair: Michael Harrison

PANEL OVERVIEW: This panel will highlight the numerous considerations that may be considered when establishing a medical operations department at a commercial space company. Traditionally, these support services have been provided by governmental assets but, with the rapid expansion of commercial human spaceflight and the ambitions to establish a sustained human presence in commercial space, the future will require commercial resources and support. We present an outline of how one company providing orbital flight opportunities approached these tasks - from staffing and team composition to development of medical standards to

adjunct support services such as search-and-rescue and console support - and integrated into a larger system that included other governmental and commercial spaceflight organizations.

[217] AD ASTRA: ONE COMPANY'S APPROACH TO MEDICAL SUPPORT FOR COMMERCIAL SPACEFLIGHT OPERATIONS

Michael Harrison¹, Melinda Hailey², Ted Duchesne², Rachel Fowler¹, John Suffredini¹, William Powers¹

¹Axiom Space Inc & Hercules Medical Group, Houston, TX, United States;

²Axiom Space Inc, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: The dawn of the commercial space industry provides opportunities for individuals and organizations that have traditionally not been able to engage in spaceflight. The medical infrastructure required to support commercial crews and their missions differs across multiple companies. This panel will introduce the audience to the broad spectrum of commercial space mission types as well as specific details at one commercial space company flying commercial crews to the International Space Station (ISS). **DESCRIPTION:** Commercial space missions differ based upon the provider and the vehicle. Mission lengths range from hours to days to weeks across the spectrum of suborbital to orbital and undocked to docked. Crew composition can vary from wealthy private individuals to governmental astronauts from non-traditional countries. The missions may terminate at the same facility from which they launched or with a landing or splashdown at a more remote location. The processes by which crews are selected, trained, medical certified, and supported for each of these missions differs. Axiom Space Inc has flown two crews to the ISS while building the first commercial space station. Axiom is developing and refining processes for medical standards, behavioral health evaluation and support, and allied-health services including support for physical fitness, nutritional and dietary, payload, and training needs that will be standard for all Axiom missions including the development of spacesuits and station modules. **DISCUSSION:** While drawing heavily on historical lessons learned and the associated experiences, the requirements and capabilities necessary to support Axiom's missions are a departure from those employed by governmental space agencies. Axiom's goal is to create a thriving home in space that benefits every human, everywhere. The medical department at Axiom endeavors to make space accessible for all while not sacrificing safety for the crew or the mission. Achieving both of these goals requires a deliberately responsible and comprehensive multidisciplinary approach that spans the preparatory, execution, and recovery stages of each mission. This panel will provide details of our approaches and successes with lessons that may benefit other individuals or organizations in the realm of commercial space.

Learning Objectives

1. Increase awareness of the differences in mission type and scope among different commercial space companies.
2. Introduce the numerous considerations required to support a safe commercial space mission to the ISS.

[218] STAFFING A MEDICAL DEPARTMENT AT A COMMERCIAL SPACE COMPANY

Melinda Hailey¹, Ted Duchesne¹, Rachel Fowler², John Suffredini², William Powers²

¹Axiom Space Inc, Houston, TX, United States; ²Axiom Space Inc & Hercules Medical Group, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: The individual members of any team are an important determinant in the efficacy and success of that team. Commercial space companies face significant challenges in determining who to include in their teams and how to develop a plan for

growth. This presentation will outline the process at Axiom Space during the progression from a newly formed company through its first International Space Station (ISS) mission to present day – repeated ISS missions, suit development, and space station planning. **DESCRIPTION:** Commercial space companies are leaner than governmental space agencies and can operate with more corporate flexibility. In the early days, the medical department relied heavily upon a small group of employees and the support of contractors. The small group of employees exhibited a balance of experience with an innovative approach and often included a positive reputation within the industry. These key positions included leadership, operational, flight surgeon, and biomedical engineer roles that may have lacked redundancy. The contracted support personnel augmented the capabilities in areas of physical fitness, nutritional, or behavioral health support; redundancy to full time personnel was often a contract position (i.e. console flight surgeon). The growth and success of the company would provide future opportunities for positions previously held by contractors to transition to full time company hires. While generally a positive event, growing pains should be expected and addressed as they present. **DISCUSSION:** The medical team of a commercial space company engaged in human spaceflight missions requires individuals who are carefully selected not only for their training and experience but also for their ability to be innovative and customer-service oriented. The company-specific mission differs from both the scope of the mission of governmental agencies but also from the scope of the mission of other entities within commercial space community. A clear corporate vision, strong leadership, and selective hiring processes with transition planning (e.g. contractor to full time) are crucial in navigating from theoretical to start-up to established commercial spaceflight provider.

Learning Objectives

1. Identifying the stages associated with a commercial space company growth.
2. Identifying the key personnel required in a medical department to support a safe and successful human spaceflight.

[219] MEDICAL STANDARDS, MEDICAL CLEARANCE AND INTERNAL/EXTERNAL RELATIONSHIPS FOR A COMMERCIAL SPACE COMPANY

William (Ed) Powers¹, Michael Harrison¹, John Suffredini¹, Rachel Fowler¹, Melinda Hailey², Ted Duchesne²

¹Hercules Medical Group/Axiom Space, Houston, TX, United States;

²Axiom Space, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: From the beginning of space exploration, candidates identified as being highly qualified for spaceflight were required to be in excellent health. The paradigm is changing as space exploration evolves into a commercial enterprise with candidates representing a wide range of age, wealth status, medical status, political and international backgrounds. Aerospace medicine physicians are challenged with mitigating the medical risk associated with flying these individuals.

OVERVIEW: Evaluation of medical risk of various conditions is essential to protect the individual and to assure success of the mission. The establishment of medical standards provides an evidence-based approach to risk acceptance. Many commercial space astronauts are self-selected due to their ability to afford the cost of the trip and may have a multitude of underlying medical issues. Each issue is considered using medical standards. Discussion of risk mitigation is undertaken based on the mission duration, activities planned during the mission, and supplies required. Other commercial space astronauts may come from international governments and are expected to fly multiple times. Selection assistance is provided to assure that career astronauts are acceptable. Consideration must also be given to the mission specific details including collaboration with NASA, international partners, and other commercial space companies. Risk acceptance is shared among those entities. **DISCUSSION:** Medical evaluation and careful

consideration of medical risk mitigation involves many factors. Relationships both internally and externally are critical to risk evaluation and acceptance. Partnering with local healthcare providers for medical evaluation and specialty consultation is utilized to provide data necessary to make decisions. Presentation to and acceptance by a certifying board is the final step in the process of clearing a commercial astronaut for spaceflight.

Learning Objectives

1. Identifying the factors associated with medical certification of a commercial space astronaut.
2. Identifying the factors that influence the development of medical standards to minimize risk to the individual and the mission.

[220] MISSION CONTROL AND OTHER OPERATIONAL SUPPORT RESOURCES AT A COMMERCIAL SPACE COMPANY

Ted Duchesne¹, Alexander Rubin¹, Melinda Hailey¹, Michael Harrison²

¹Axiom Space Inc, Houston, TX, United States; ²Axiom Space Inc & Hercules Medical Group, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: It takes hundreds of people to support one astronaut during a spaceflight mission. A commercial astronaut draws on resources across multiple organizations including governmental space agencies and partner commercial space entities but, in some cases, traditionally available government support resources are not an option. A commercial space mission represents an opportunity to innovate, integrate, and iterate the operational support paradigm that is crucial to the safety and success of human spaceflight. **DESCRIPTION:** The most common support resource that is associated with human spaceflight is the mission control center (MCC). Commercial space missions at Axiom Space have required the integration of an internal MCC with those of NASA and SpaceX across multiple sites during dynamic mission phasing. Upcoming missions have added the requirements to integrate further with the MCC of an international partner within the current system. Search and rescue (SAR) and hyperbaric resources for human spaceflight have traditionally been provided through inter-agency governmental cooperation, specifically between NASA and the Department of Defense (DOD). Commercial spaceflight missions are not eligible for this level of DOD support and commercial companies are required to contract civilian SAR and hyperbaric resources. These assets may have their own MCC and will require integration within the larger MCC network during, at a minimum, the launch and landing phases of the mission. These items represent select high-profile examples but multiple other aspects of mission support including but not limited to payload coordination, flight-hardware certification, exercise devices and prescription, and crew and family psychological support also represent opportunities to change how support is provided to human spaceflight in the age of commercial operations. **DISCUSSION:** The model of integrated operational support for human spaceflight is changing at a rapid pace from that employed by governmental space agencies to those provided by commercial companies. Many of the resources that may be taken for granted require commercial companies to develop and refine their own capabilities and processes. This represents a very important and deliberate undertaking to maximize mission success and crew safety.

Learning Objectives

1. The audience will learn about the integration that is required to support a commercial space mission to the ISS.
2. The audience will be able to identify aspects of spaceflight mission support that also need to transition from government to commercial sectors beyond the launch vehicle provider.

[221] MEDICAL DEPARTMENT INTEGRATION WITHIN A COMMERCIAL SPACE ORGANIZATION

Lindsey Hieb

Axiom Space Inc, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: A physician trained in Aerospace Medicine, with the relevant clinical knowledge and medical authority, is required for direct patient care. However, fully applying that knowledge and authority where needed across a commercial space organization requires effective integration of the medical operations group with the rest of the organization.

OVERVIEW: From the earliest days during the establishment of a medical operations department, there will be situations where a representative from medical needs to weigh in as a stakeholder regarding potential impacts to human health or the exchange of medical data, as well as provide information where medical industry knowledge is required to make operational, planning, or design decisions. Considerations for the scope of that work as the company grows may include writing and verifying requirements; designing or sourcing and testing hardware; and developing and documenting processes, standards and procedures. In an operations environment, needs may also include review of mission products from a medical perspective. The medical operations department should also weigh in on the handling of medical data and development of processes associated with human research payloads. This integration requires effectively interpreting and relaying information between physicians and the operations and engineering communities within an organization, to name a few, while balancing differing priorities. It may require human health related content development tailored to fit certain applications, and participation in working groups or boards where multiple departments work together to create integrated products or make decisions. **DISCUSSION:** A highly functioning medical department is not based on the possession of specialized clinical knowledge and expertise alone. Effectiveness is dependent upon using that knowledge while participating in the right conversations across an organization, wherever those conversations are occurring. It is best to establish an integrated presence as early as possible to open up lines of communication and create productive relationships.

Learning Objectives

1. The audience will learn about likely interfaces between medical operations and other departments in a commercial space organization.
2. The audience will be able to identify examples of tasks or products requiring integrated participation from medical operations.

Tuesday, 05/07/2024**4:00 PM****Grand Ballroom A****[S-41]: SLIDES: BONES, MUSCLES AND CENTRIFUGES - OH MY****Chair: Jennifer Fogarty****Co-Chair: Megan Gallo****[222] HEAD DOWN TILT BED REST STUDIES AND EYE EXAMINATIONS FOR TEST SUBJECTS SAFETY**

Claudia Stern, Stefan Kremers, Maren Pittius, Doris Mittelstaedt, Steffen Stupp, Laura de Boni, Edwin Mulder, Scott Ritter
German Aerospace Center, Cologne, Germany

(Education - Program/Process Review)

BACKGROUND: Prolonged head-down tilt bed rest (HDTBR) is frequently employed as an analog to study the human physiology changes that occur during spaceflight, particularly Spaceflight Associated Neuro-ocular Syndrome (SANS). We conducted four HDTBR campaigns to investigate ocular changes and potential SANS countermeasures. To ensure the safety of test subjects and the quality of data, we established specific exclusion criteria and implemented safety examinations. **OVERVIEW:** 39 test subjects underwent a 30-day period of strict HDTBR. Comprehensive ocular assessments were conducted at baseline and during the immediate recovery phase following HDTBR. This included measurements of visual acuity, refraction, visual field, applanation tonometry, slit lamp, optical coherence tomography (OCT) and funduscopy. Measurement of intraocular pressure

(IOP) and near visual acuity was added at day 2, 4, 17 and 30 of the HDTBR period. One test subject developed a retinopathy centralis serosa and was subsequently excluded during baseline examination. Another showed a retinal hole in the periphery which was detected with dilated funduscopy during baseline examination and was treated by laser before bedrest started. Two eyes of two participants showed a reduction of two and three lines of near visual acuity at day 2 of bed rest. After bed rest, near visual acuity of one eye showed one line of reduction, while the other eye was back to baseline. There was no significant hyperopic shift in refraction and no optic disc edema in these eyes. For all participants, IOP during bed rest had a range of 12.2 to 27.6 mm Hg, with the highest values at day 4 and 17. **DISCUSSION:** The observed increase in IOP highlights the importance of IOP safety measures during HDTBR. Near visual acuity testing does not give enough information concerning hyperopic shift and reduced eye length due to different influences on near vision and a lack of hyperopic shift in bed rest. We emphasize of conducting a comprehensive eye examination with visual acuity testing, applanation tonometry, visual field testing, OCT, slit lamp and dilated funduscopy. Additionally, the exclusion of eye pathologies is important to ensure test subjects safety during HDTBR.

Learning Objectives

1. The audience will learn about recommended ocular safety measurements in head down tilt bed rest studies.
2. The audience will learn about the results of near visual acuity and intra-ocular pressure measurements during head down tilt bed rest studies.

[223] PREVENTION OF VISUAL SYMPTOMS DURING CENTRIFUGE-SIMULATED SUBORBITAL SPACEFLIGHT

Ryan Anderton¹, Thomas Smith², Ross Pollock², Joseph Britton³, Nicholas Green³, Daniel Hendriksen³

¹UK Civil Aviation Authority, Gatwick, United Kingdom; ²King's College London, London, United Kingdom; ³RAF, Henlow, United Kingdom

(Original Research)

INTRODUCTION: Previous centrifuge research has identified that during a centrifuge simulated suborbital spaceplane launch involving +4Gz and up to +4.5Gx, ~70% of individuals experienced greyout, increasing to ~80% on re-entry, assuming an upright seated posture. Furthermore, blackout and G-induced loss of consciousness (G-LOC) have been observed during the same profiles. A potential means to mitigate this risk is to instruct passengers/crew to tense their legs/abdominal muscles in a similar manner to that performed during the anti-G straining maneuver. The aim of the current study was to determine whether pre-tensing of the lower body muscles can prevent visual symptoms during suborbital acceleration profiles, thereby reducing the risk of G-LOC. **METHODS:** 13 participants (10 males, 3 females, age range 34-82, mean age 53 (SD= 15)) who had previously experienced G-induced visual symptoms during a centrifuge suborbital spaceflight acceleration study were invited to take part. The acceleration profile used was the most provocative suborbital profile identified in a prior study, mimicking spaceplane launch and re-entry in an upright seated position. Participants experienced acceleration while relaxed and when performing lower body muscle tensing, initiated ~10 seconds prior to peak acceleration. Participants were asked to depress a marker button while they experienced any visual symptoms to record onset and duration. The study had favorable opinion from the UK Ministry of Defence Research Ethics Committee. **RESULTS:** Pre-tensing completely prevented greyout on launch in participants who had previously experienced greyout during suborbital profiles when relaxed, and on re-entry it prevented greyout in 54% of participants. The time to onset of greyout in those who experienced re-entry symptoms was delayed by muscle tensing. The effectiveness of pre-tensing was not related to age. Pre-tensing was well tolerated. **DISCUSSION:** Greyout can be common during launch and re-entry phases of centrifuge-simulated suborbital spaceflight in a seated spaceplane profile. Pre-tensing was found to be well tolerated and feasible for suborbital spaceplane participants and should be considered as a mitigation during

routine operations. Even with pre-tensing, individuals may still experience G-related visual symptoms, indicating that the risk of G-LOC remains.

Learning Objectives

1. The audience will learn about the effectiveness of muscle tensing in preventing visual symptoms in a centrifuge-simulated upright seated spaceplane profile.
2. The audience will learn that the effectiveness of pre-tensing in this study and simulated spaceplane profile was not related to age.

[224] TOLERANCE OF CENTRIFUGE-SIMULATED SPACEFLIGHT IN INDIVIDUALS WITH DIABETES

Samantha King, Rebecca Blue
UTMB, Galveston, TX, United States

(Original Research)

INTRODUCTION: There is increasing interest in the screening and evaluation of individuals with underlying medical conditions such as diabetes for participation in commercial spaceflight. Limited data exist regarding tolerance of centrifuge-simulated spaceflight in diabetics. Of concern, diabetes and glycemic control medications may risk incapacitation through hypoglycemic or hyperglycemic events. This study evaluated the tolerance of simulated spaceflight in diabetics. **METHODS:** Layperson volunteers were recruited for centrifuge studies simulating spaceflight in both capsule and fixed-wing vehicles. All centrifuge studies were approved by the University of Texas Medical Branch Institutional Review Board. Prior to participation, volunteers were required to provide medical screening documentation. Diabetic exclusion criteria included HbA1c >8% or preprandial blood glucose average >250mg/dL. Twenty (3 female) diabetic volunteers met screening criteria for inclusion. Diabetic participants utilized various methods of glycemic control including diet, oral medications, and insulin. Participants underwent ≤7 centrifuge spins over 1-2 days. Monitors collected vital sign data prior to and during centrifuge spins; subjects completed post-spin symptom questionnaires. **RESULTS:** Diabetic subjects demonstrated similar hypergravity tolerance compared to non-diabetic laypersons. Two diabetic participants did not complete all pre-determined centrifuge runs, in one case secondary to motion sickness and the other for scheduling constraints. Glycemic control methods (insulin vs non-insulin) were not associated with differences in tolerance. There were no statistical differences in vital signs or symptoms between diabetics and the general cohort. Diabetic participants were more likely to report nausea than laypersons (35% versus 16.7%) though not a statistically significant difference. One participant on a sulfonylurea had a transient suspected hypoglycemic event after a centrifuge spin in the setting of decreased oral intake prior to participation. **DISCUSSION:** Diabetes poses a risk of incapacitation in high performance environments due to the risk of hypo- or hyperglycemia. However, these data suggest that, with appropriate screening and stratification, diabetic individuals can successfully tolerate spaceflight hypergravity exposures. Further research into the effects of other aspects of spaceflight on diabetics may allow for inclusion of such individuals in future flight.

Learning Objectives

1. The participant will understand the hemodynamic impacts of simulated spaceflight hypergravity exposures in diabetic individuals.
2. The participant will understand the impact of methods of glycemic control on diabetic individuals in simulated spaceflight hypergravity exposure.

[225] WHAT YOU NEED TO KNOW ABOUT THE MUSCULOSKELETAL SYSTEM IN MICROGRAVITY

Vaishnavi Rathod¹, Darshankumar Raval², Shahin Khan³, Shashwat Mallik³, Musharrafah Ansari³, Het Contractor³, Milauni Dave³, Devang Gohel³, Kajal Patel³, Leigh Speicher⁴
¹Parul Institute of Medical Sciences, Vadodara, India; ²Mayo Clinic, Jacksonville, FL, United States; ³Government Medical College, Baroda, Vadodara, India; ⁴Mayo Clinic, Jacksonville, FL, United States

(Education - Tutorial/Review)

INTRODUCTION: Microgravity in space has significant detrimental effects on the musculoskeletal system (MSK), including bones, muscles, and intervertebral discs (IVD). Studies on astronauts, bed-rest patients, and animals have consistently shown a decrease in trabecular and cortical bone density, muscle atrophy, and an increased risk of IVD herniation. **TOPIC:** The bone density loss is more evident in weight-bearing bones, especially those of the lower limb. This is attributed to imbalances between osteoblast and osteoclast activity, changes in integrin signaling mechanisms, and mitochondrial disruption. Moreover, microgravity leads to imbalances in calcium-phosphorus homeostasis, with increased urinary calcium and bone resorption markers, and decreased bone formation markers. These changes are also heavily influenced by the duration of microgravity. Muscle atrophy is another consequence of microgravity, affecting various muscle groups, especially the multifidus and ankle extensors. Changes in muscle volume are attributed to a reduction in the Daily External Loading Stimulus and altered metabolism of muscle fibers, along with a decrease in the capillaries supplying each fiber. Long-term exposure to microgravity also results in a reduction of muscle strength, with calcium levels in muscle fibers playing a critical role. IVDs experience changes in volume and hydration due to unloading in microgravity. Hence, astronauts are 4.3 times more likely than the general population to experience disc herniation. Fluid flow and nutrition to the discs are affected, similar to the degeneration seen in aging discs. Diurnal changes in fluid flow are disrupted in space. Previous high-performance jet pilot training seems to be protective.

APPLICATION: Countermeasures, like exercise protocols, are essential to mitigate the adverse effects of microgravity. Aerobic and resistive exercises, especially personalized cycling exercises, have been found effective in preserving muscle mass, muscle strength, and bone density. However, it remains challenging to expel excess fluid from intervertebral discs in a microgravity environment. Newer exercise regimes are required because even though the current ones are effective, they are not adequate as our astronauts continue to suffer from MSK pathologies post-flight. Further research is needed to better understand the mechanisms underlying these effects and to develop targeted countermeasures to protect the MSK during spaceflight.

Learning Objectives

1. The audience will understand the impact of microgravity on bones, muscles, and intervertebral discs.
2. The audience will know about the current status of countermeasures, and whether they are effective in protecting the musculoskeletal system of astronauts.

[226] MECHANICAL ANALYSIS OF A 3-D PRINTED EXTERNAL FIXATOR DESIGN FOR LONG DURATION SPACE FLIGHT FRACTURE CARE VERSUS INDUSTRY STANDARD EXTERNAL FIXATORS

Nathan Skelley¹, Lisa MacFadden², Clint Boerhave³

¹Sanford Health - The University of South Dakota School of Medicine, Sioux Falls, SD, United States; ²University of South Dakota, Sioux Falls, SD, United States; ³ViaFlex, Sioux Falls, SD, United States

(Original Research)

INTRODUCTION: External fixation is a critical component of orthopaedic fracture management and can treat a diverse range of complex bone fractures. However, medical grade external fixators can cost between \$4,000-\$6,000. The availability, equipment size, and high cost of external fixation devices are a concern, especially in long duration space flight missions. In these settings, it would not be practical to transport an entire orthopaedic surgical suite and the associated equipment and implants for all possible fracture types. 3-D printing technology has shown promise as a method for reducing costs, customizing fracture treatment, and improving accessibility to external fixation devices. The purpose of this study was to evaluate the mechanical properties of a fully 3-D printed desktop external fixation device and compare the results

with the mechanical properties of commonly used, clinically available external fixators. **METHODS:** A fully 3-D printable external fixator was designed and printed in polylactic acid at two infill densities, 20% and 100%. The mechanical properties of the 3-D printed external fixators and several commercially available fixators were tested according to applicable sections of the American Society for Testing and Materials F1541 standard protocol in axial, medial-lateral, and anterior-posterior orientations. The primary outcomes measured included failure load, safe load, rigidity, and yield load. The mean differences between experimental and control groups were calculated using one-way ANOVA and Tukey tests. **RESULTS:** The 20% infill 3-D printed construct performed poorly compared to commercially available external fixators in all testing conditions and across most variables. The 100% infill 3-D printed construct was comparable or superior to all commercially available devices in most testing conditions. The cost for printing a single 3-D printed 100% infill external fixator was \$14.49. The entire external fixator could be printed in less than two days. **DISCUSSION:** This study demonstrates that a low-cost desktop 3-D printer can create an entirely 3-D printed external fixator that resists clinically relevant forces similar to medical grade industry standard external fixators. This device can be printed on demand and customized to various fracture types. The findings of this study support the potential for customizable and low-cost external fixators to be manufactured with desktop 3-D printing for use in long duration space flights.

Learning Objectives

1. Can a novel low cost desktop 3-D printer create an external fixator for fracture management that meets the same mechanical criteria for fracture stabilization as a medical grade carbon fiber and stainless steel construct?
2. How can 3-D printing improve storage, print-on-demand, and reuse for medical equipment in long duration space flight?
3. What are common fractures that astronauts are at risk of sustaining that can be treated with an external fixator device?

[227] BONE DENSITY CHANGES IN MICROGRAVITY: A SYSTEMATIC REVIEW

Darshankumar Raval¹, Shashwat Mallik², Shahin Khan², Dana Herrigel¹, Leigh Speicher¹

¹Mayo Clinic, Jacksonville, FL, United States; ²Government Medical College, Baroda, Vadodara, India

(Original Research)

INTRODUCTION: Research into bone alterations in microgravity has primarily focused on two key aspects: bone mineral density (BMD) and the markers of bone formation and resorption. The aim of this review, therefore, is to determine the effects of natural or simulated microgravity on BMD of different bones, and the biochemical bone markers, along with recommendations for exercise regimes or pharmacotherapies. **METHODS:** A literature search was carried out using the PubMed database, which yielded 626 results. The following inclusion criteria were applied: (1) either the BMD or the bone formation/resorption markers were reported, (2) the data collected was primary, that is, only original articles, case reports, and case series, (3) the population of the study was humans, (4) the study was conducted in microgravity, either natural or simulated. **RESULTS:** A total of 54 articles were included in the final systematic review. Twenty-eight of these were observational studies while 26 involved some sort of intervention - particular exercise regimens, strict diets, supplements, or pharmacological agents. Twenty-three studies were conducted during spaceflight, while simulated microgravity was used in 29. Two employed both spaceflight and bed rest to derive results. DEXA Scan (n=27) and quantitative-CT (n=12) were commonly used to determine the BMD. Twenty-five studies measured urinary calcium and bone formation/resorption markers to determine bone resorption. The lumbar spine and hip were the most common sites for BMD measurement, and both showed significant losses in microgravity. The radius was largely unaffected. Resistance training was the most commonly employed intervention, but the effectiveness

of bisphosphonates (n=7) and supplements (n=3) was also studied.

DISCUSSION: Prolonged exposure to microgravity, during spaceflight and bed rest, results in significant losses of BMD in weight-bearing bones, but not in non-weight-bearing areas of the upper limb. The changes in bone markers occur earlier than radiologically detectable BMD loss, but they also recover rapidly once the exposure to microgravity ends, and thus, cannot be surrogate markers during recovery. The current exercise protocols are only partially effective at preventing microgravity-induced osteoporosis, and hence, we recommend more rigorous training regimes combined with pharmacotherapies like bisphosphonates and omega-3 fatty acids.

Learning Objectives

1. The audience will understand the impact of microgravity on human bones.
2. The audience will learn about the number of observational and interventional studies conducted on human bones in microgravity.
3. The audience will understand the types of bones involved and the interventions aimed at preventing bone density loss.

Tuesday, 05/07/2024
Grand Ballroom B

4:00 PM

[S-42]: PANEL: INTERNATIONAL AEROSPACE NEUROSCIENCES CONSORTIUM (IANC)- PATENT FORAMEN OVALE (PFO), FROM ONE END OF THE ROPE SCORE TO THE OTHER

Chair: Joseph Connolly

Co-Chairs: Roger Hesselbrock

PANEL OVERVIEW: TITLE: International Aerospace Neurosciences Consortium (IANC)- Patent Foramen Ovale (PFO), From one end of the RoPE Score to the other Panel Chair: Joseph Connolly III, DO, MPH Panel Co-Chair: Roger Hesselbrock, MD Panel Type: Educational Review and Case Studies BODY: Patent Foramen Ovale (PFO) is a congenital heart finding seen in approximately 25% of the population and often benign. However, PFO has been implicated in embolic disease processes to include cerebrovascular accident (CVA), neurological decompression sickness, and migraine with aura. In aircrew these outcomes can lead to sudden incapacitation and long-term disability. Closure of the PFO has short and long-term implications that must guide aeromedical disposition. This panel will include a tutorial on patent foramen ovale (PFO). Following the tutorial, a variety of cases of aircrew (predominantly pilots) with neurological events who were found to have PFO will be presented. These case presentations will include diagnostic decision making regarding the event of concern and its etiology including whether or not the PFO was implicated. The actual and potential complications of PFO, PFO closure, and other management options will be presented. Finally aeromedical implications, waiver recommendations and certification decisions will be discussed. Cleared: AFRL-2023-5373

[228] PATENT FORAMEN OVALE IN AIRCREW – IMAGING, DIAGNOSIS AND GRADING.

Eddie Davenport

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Patent Foramen Ovale (PFO) is a congenital heart process seen in approximately 25% of the population and often benign. However, PFO has been implicated in embolic disease processes to include cerebrovascular accident (CVA) and peripheral vascular processes such as headache. In aircrew these outcomes can lead to sudden incapacitation. Closure of the PFO has short and long-term implications that must guide aeromedical disposition. **TOPIC:** The latest published recommendations for imaging and treatment options for PFO will be discussed in detail. Actual PFO images will be presented so the audience may view a PFO and learn the diagnostic criteria and grading. Recently published

data regarding long term risk of PFO closure will also be discussed to include development of atrial fibrillation and atrial flutter. Finally, current aviator specific diagnostic and management guidance will be discussed. **APPLICATION:** PFO is a common finding on echocardiogram and seen in approximately 25% of the population. Understanding the diagnosis, treatment options, risk vs benefit, and long-term implications of closure of PFO is necessary for proper aircrew disposition.

Learning Objectives

1. Describe the characteristics of a Patent Foramen Ovale. What is it and how does it look on echocardiogram.
2. Learn the pathological processes associated with a PFO and their aeromedical implications.
3. Understand the treatment options for PFO and their aeromedical implications.

[229] HOW MUCH ROPE? A CASE STUDY OF PILOT WITH A TIA AND PFO.

Christopher Skinner

University of Ottawa, Ottawa, ON, Canada

(Education - Case Study)

This case presentation reviews the clinical decision-making process associated with a 46-year-old transport pilot who experienced a left hemisphere TIA and was found to have a moderate-sized PFO. The TIA was characterized by a fall and left leg weakness following prolonged sitting while driving. The event lasted approximately 30 minutes. Neurological exam showed no residual focal deficits. There was no infarct on MRI imaging, the CTA showed a bihemispheric left dominant ACA. The stroke workup was negative except for a positive bubble study showing a moderate PFO at rest. Given the history of prolonged travel/relative immobility in the setting of a moderate PFO, the most likely mechanism of his stroke was thought to be a paradoxical embolism. This was supported by a ROPE score of 7 points which conferred a 72% likelihood of PFO being the causative mechanism. His ROPE score is also in keeping with a 6% chance of future vascular event in the next 2 years. The recommendation was made to close the PFO which was successfully completed and the pilot has been returned to flight status. The presentation will discuss the decision-making process associated with the management of this case. There will be a discussion on how the ROPE scale is used and how it does not consider the environmental stresses and risks associated with the aerospace environment. There will also be a discussion on what modifications might be recommended to current practices to provide guidance to Aviation Medical Examiners and Flight Surgeons.

Learning Objectives

1. Present a case study of a pilot with a TIA and a PFO.
2. Discuss the decision making process associated with the management of case.
3. Discuss the ROPE scale and how it may not consider the environmental stresses associated with the aerospace environment.

[230] ISCHEMIC STROKE AND PFO CLOSURE IN A HIGH-PERFORMANCE AVIATOR

Aven Ford

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case report describes a military single-seat high-performance pilot who suffered an ischemic stroke and was found during the evaluation to have a patent foramen ovale which was subsequently closed with a Gore Cardioform® device. **BACKGROUND:** Ischemic stroke (IS) is uncommon in young patients, with adults aged 18-50 years of age accounting for only 10-15% of all strokes. However, IS is associated with significant morbidity and mortality at any age. Evaluation and treatment is targeted at finding a reversible or treatable cause of IS in order to decrease the risk of future stroke. Cardiac sources,

including patent foramen ovale (PFO), account for approximately 20% of all ischemic strokes in young patients. In aviators, outcomes of concern include recurrent stroke, seizure, and arrhythmia. In addition, there are G-related concerns in the high-performance aviator that include device migration or failure. **CASE PRESENTATION:** The subject is a single-seat, high-performance pilot in his mid-thirties with a total of 900 flying hours who presented to the ER with incoordination and numbness in his left hand and spurred speech in the morning after awaking. His symptoms resolved within 16 hours. MRI showed findings consistent with an embolic IS. Transthoracic echocardiogram showed a PFO with intracardiac shunting. The PFO was closed with a Gore Cardioform® device several weeks after the event. Follow-up brain MRI showed residual gliosis and hemosiderin deposition in the right postcentral gyrus. He has had no new or recurrent symptoms and no episodes concerning for seizure. Neurologic examination findings have consistently been noted as normal. An EEG was unremarkable. He is now 30 months post-stroke.

DISCUSSION: PFO closure remains a topic of some controversy. PFOs are a common incidental finding in the general population and it cannot be proven as a cause of any single IS. With his PFO closed, at the time of his evaluation, his annualized risk of stroke is well under 0.5% (approximately 0.2% annually). However, his combined risk of stroke and seizure was estimated to be approximately 1-2% per year. His risk of device failure and device migration in high-performance flight could not be estimated, as these devices have not been studied in high-Gz in human subjects or animal models. He was recommended for a 1-year waiver restricted to non-high performance, multiplace airframes.

Learning Objectives

1. The participant will understand how to approach the aviator with ischemic stroke and PFO.
2. The participant will understand the appropriate restrictions of aviators after ischemic stroke and PFO closure.
3. The participant will understand the rationale for observation periods following ischemic stroke.

[231] EMBOLIC ISCHEMIC CORTICAL STROKE IN A 28-YEAR-OLD FLIGHT INSTRUCTOR WITH A SMALL PATENT FORAMEN OVALE

Anthony Rengel¹, Christian Gericke²

¹Royal Flying Doctor Service, Kalgoorlie, Australia; ²University of Queensland Medical School, University of Newcastle School of Medicine and Public Health, and Calvary Mater Hospital, Newcastle, Australia

(Education - Case Study)

INTRODUCTION: This case describes a young flight instructor who suffered an embolic ischemic stroke with punctate lesions in his right motor and superior parietal cortex. Investigations revealed a small patent foramen ovale (PFO). **BACKGROUND:** Stroke in young patients is frequently associated with a PFO. Controversy exists over whether the PFO is a cause, a risk factor, or an incidental finding in these cases. Estimating the individualised risk of stroke recurrence is difficult to ascertain. This has implications for medical certification for pilots following recovery. **CASE PRESENTATION:** A 28-year-old male recreational flight instructor held a Commercial Pilot Licence with approximately 2000 hours of flight experience. He presented to the hospital with sudden onset left-sided facial paraesthesia, left hand weakness and blurred vision, accompanied by gradual onset, moderate severity, bilateral headache. The cranial symptoms resolved within 30 minutes. The left hand weakness persisted for three days. MRI revealed two punctate ischemic foci in the right precentral gyrus and superior parietal lobe. Vasculitis and thrombophilia screen, CT angiography, lower limb Doppler, 7-day Holter monitoring, and stress echocardiogram were normal. Transesophageal echocardiogram revealed a PFO with small bidirectional shunt. The cardiologist and neurologist opined that the PFO was unlikely to have caused his stroke and estimated an annual recurrence rate of <1.8%. The pilot was placed on life-long aspirin and atorvastatin. He was offered PFO closure but declined. Under

Recreational Aviation Australia rules, he was able to return to flying light sport aircraft. However, an enduring co-pilot restriction for general aviation activities was placed on his Class 1 and 2 Aviation Medical by the Australian Civil Aviation Safety Authority. Following a review two years later, the restriction was upheld despite no stroke recurrence.

DISCUSSION: This case highlights the difficulty in determining individualised risk for pilots recovering from a stroke associated with a small PFO. Whilst treatment with aspirin and a statin or PFO closure reduces the risk of stroke recurrence, these treatments carry a risk of side effects. Further evidence is required to better individualise risk for stroke patients with a small PFO to determine optimal treatment options and to stratify their suitability for medical aviation re-certification.

Learning Objectives

1. Understand the relevance of the finding of a patent foramen ovale following ischemic stroke in young patients.
2. Appreciate the current difficulties in stratifying and individualising stroke recurrence risk in patients with patent foramen ovale and the implications this has on aeromedical re-certification following recovery.
3. Develop an awareness of different aeromedical certification standards based on activity type and jurisdiction.

[232] PFO, ATRIAL FIBRILLATION AND STROKE IN A COMMERCIAL PILOT

Roger Hesselbrock, Richard Murphy, Farhad Sahiar
FAA, Oklahoma City, OK, United States

(Education - Case Study)

INTRODUCTION: This case report describes a pilot who experienced neurologic symptoms and was found to have subcortical infarctions. Patent foramen ovale (PFO) was identified during evaluation, was felt contributory, and was later percutaneously closed. Atrial fibrillation was noted following PFO closure and was felt a peri-procedural complication. **BACKGROUND:** Cryptogenic stroke and embolic stroke of undetermined source (ESUS) are frequently assessed diagnoses on initial stroke evaluation. Paradoxical embolization through a PFO is a commonly-implicated etiology. Undiagnosed atrial fibrillation is also a concern with cryptogenic stroke or ESUS. Guidance on medical management of PFO and indications for PFO closure have historically varied.

CASE PRESENTATION: A 57 year old nonhypertensive, nondiabetic, nonsmoker pilot had a previous episode of transient arm numbness and weakness that had not been evaluated. Three months later he had more extensive symptoms, including cognitive dysfunction, and was treated with thrombolysis. Brain MRI showed two small areas of subcortical posteromedial thalamic infarction. Vascular imaging and hypercoagulability assessments were negative. Echocardiography showed PFO with atrial septal aneurysm and intracardiac shunting. Risk of Paradoxical Embolism (RoPE) score was 6, indicating 62% likelihood of PFO-attribution. PFO closure and implantable loop monitor (ILR) insertion were done two months after the stroke. Atrial fibrillation was noted on initial ILR reports, with latest occurrence 46 days following PFO closure, and was managed with anticoagulation. No further atrial fibrillation was noted on ILR reports. **DISCUSSION:** This case highlights challenges in managing PFO in the setting of stroke. Determination of stroke etiology and potential contribution from PFO can be difficult. Utility of the RoPE Score tool in PFO management will be discussed. Peri-procedural atrial fibrillation is a common complication following PFO closure and has different implications than otherwise discrete atrial fibrillation regarding future stroke risk. FAA medical certification requirements will be presented and discussed.

Learning Objectives

1. The audience will have increased understanding of the association and implication of atrial fibrillation detected after PFO closure.
2. The audience will have increased understanding on the utility of the RoPE score in PFO management.

[233] I GOT BENT; BLESS YOUR HEART: A CASE STUDY

Roy Hoffman

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

(Education - Case Study)

INTRODUCTION: This is a case of type II decompression sickness (DCS) in a military diver with a patent foramen ovale (PFO) discovered during their post event evaluation. **BACKGROUND:** Type II DCS is a rare event with reported incidence among commercial divers ranging from 1.5 - 10 per 10,000 dives. PFO is present in approximately 30% of the normal population and produces a 2.5 times increase in the odds ratio for developing type II DCS. A vascular gas embolism can arterialize through a PFO with sufficient circumstances to include large amounts of gas emboli, PFO grading, straining maneuvers, and delayed desaturation. Routine screening for PFO in military dive physicals does not occur but are performed if DCS occurs with neurological symptoms. **CASE PRESENTATION:** The subject is a 50-year-old female military diver with 21 years of experience who after a hyperbaric chamber "dry dive" of 130 feet for 20 minutes awoke symptomatic in the middle of that night. She first noticed bilateral numbness of the extremities, then global weakness and ataxia. On exam she had hyperreflexia, clonus, personality changes, and cognitive deficits to include inability to perform serial sevens and draw a proper clock face. She had 7 treatments of hyperbaric oxygen using a Navy Table 6. On further evaluation a PFO was found and subsequently the patient elected to have it closed. MRI revealed thoracic abnormalities. **DISCUSSION:** This case highlights the known DCS risk factor of PFO and reveals that many hours and years of dive experience should be used to rule out the presence of a PFO in any case with type II DCS. It also reveals that a diver does not have to get wet to experience a significant case of DCS and that onset of symptoms can be slow to develop. While the incidence of type II DCS in the military does not support PFO screenings, the evaluation of a diver after a case of type II DCS should include a bubble study regardless of the diver's hours or prior experience. A diver can recover from an event and be granted a waiver after a type II DCS event even if sequelae remain.

Learning Objectives

1. The audience will understand that PFO is a risk factor for type II DCS.
2. The audience will understand that DCS can occur in a diver with an unknown PFO after many dives and years of diving experience.
3. The audience will understand that the symptoms of type II DCS can occur many hours later and progress over time.

Tuesday, 05/07/2024
Grand Hall J

4:00 PM

[S-43]: SLIDES: ADVERSE ENVIRONMENTS AND HUMAN PERFORMANCE

Chair: Paul Young

Co-Chair: Justin Lafreniere

[234] ANALYSIS OF HELICOPTER AIR AMBULANCE AVIATION SAFETY REPORTING SYSTEM (ASRS) DATA

Hannah Baumgartner¹, Justin Durham², Rebecca Didomenica², Peter Hu²

¹FAA, Oklahoma City, OK, United States; ²Cherokee Nation Support, Services, & Solutions, Oklahoma City, OK, United States

(Original Research)

INTRODUCTION: Helicopter air ambulance (HAA) operations are associated with unique risks and human factors considerations due to the on-call nature of the work, low altitude operations, and routes to novel locations. Assessing events voluntarily reported to the Aviation Safety Reporting System (ASRS) database provides important information

about precursors to risk in these operations. **METHODS:** The National Aeronautics and Space Administration's (NASA) ASRS database was queried for reports that related to 14 C.F.R. Part 135 and HAA operations between 2013 and 2023. Reports were then filtered to include only those referencing rotorcraft. Narratives, synopses, and event data were evaluated for overall trends across reports. Trends were identified with a coding scheme that iteratively examined organizational factors, event and personnel data, errors, and unsafe conditions. **RESULTS:** A total of 97 ASRS reports were analyzed. Most reports were flightcrew related ($n = 84$; 87%), while others documented issues with maintenance ($n = 17$) or Air Traffic Control (ATC; $n = 12$). The most frequently reported issue was lack of situation awareness or the ability to perceive, understand, and respond to events ($n = 57$), followed by pilot/ATC communication challenges ($n = 35$), judgment/decision-making errors ($n = 24$), and errors adhering to procedure ($n = 21$). Organizational factors related to policy/procedural issues ($n = 15$), commercial performance pressures ($n = 13$), and safety culture issues ($n = 6$) were also identified. The most frequently reported consequence was on aircraft systems or components ($n = 24$), followed by near mid-air collisions ($n = 14$), loss of control ($n = 3$), or impacts to patient outcome ($n = 7$). **DISCUSSION:** Analyses of ASRS reports related to HAA operations identified a range of risk factors and safety critical areas to address in Part 135 and HAA operations. Findings suggest that training and interventions related to situation awareness, communication between pilots and ATC, and maintenance operations would be useful in mitigating future accidents or incidents. Other organizational factors identified included policy issues, procedural issues, and commercial pressures, which suggest room for growth in HAA operations to improve safety outcomes.

Learning Objectives

1. Understand current safety risks in helicopter air ambulance operations using voluntary safety reporting data.
2. The audience will learn about current human factors considerations in helicopter air ambulance operations.

[235] RISK CHARACTERIZATION OF POLARIS DAWN EVA DEPRESS PROFILE IN NASA'S 20FT CHAMBER

Marissa Rosenberg¹, Andrew Abercromby², Amran Asadi¹, Diana Dayal¹, Edgar Lichar Dillon³, Patrick Estep³, Alejandro Garbino³, Monica Hew³, Esther Putman¹, Brett Siders³, Jaime Mateus¹

¹Space Exploration Technologies, Hawthorne, CA, United States; ²NASA, San Luis Obispo, CA, United States; ³NASA/KBR, Houston, TX, United States

WITHDRAWN

[236] ACCURACY AND PRECISION OF PULSE OXIMETERS IN EXTREME HIGH-ALTITUDE HYPOXIA SIMULATION

Jon-Arild Kjeserud¹, Harald Vikne¹, Nils Henrik Holmedahl¹, Gjøvåg Terje², Jon Ingolf Medbø³, Jan Ivar Kåsin¹, Willy Westgaard¹

¹Norwegian Institute of Aviation Medicine, Oslo, Norway; ²Oslo Metropolitan University, Oslo, Norway; ³Western Norway University of Applied Sciences, Sogndal, Norway

(Original Research)

INTRODUCTION: In military hypoxia recognition training, participants often experience severe hypoxia, with oxygen saturation levels nearing 50%, as measured by pulse oximeters. However, clinical standards for pulse oximeter validation require only measurements between 70% and 100% oxygen saturation. This study aims to assess the accuracy and precision of four pulse oximeters when measuring oxygen saturation below 70%. **METHODS:** Seventeen healthy adult volunteers (7 women and 10 men) were sitting at rest and exposed to varying oxygen concentrations (8 – 21%) in the inspired air to establish stable

arterial oxygen saturation levels between 55% and 100%. We collected 3-5 simultaneous measurements from four pulse oximeters and of arterial blood samples using a reference hemoximeter for each oxygen concentration. Data analysis involved assessing bias and variability using the Bland-Altman Limit of Agreement method (LoA) and root mean square error (RMSE) within three saturation intervals: 55-70%, 70-85%, and 85-100%. **RESULTS:** At the 85-100% saturation range, all pulse oximeters demonstrated minimal bias (ranging from -0.3% to 2%) and moderate variability (LoA between +/- 2.8% and 3.8%). In the 70-85% range, biases ranged from -3% to 3.8%, and variability increased (LoA range +/- 3.9% – 5.7%). At 55-70% saturation, biases varied from -2.5% to 5.0%, with expanded LoAs (+/- 5.2% to 8.2%). The RMSE between pulse oximeters was 1.4% to 2.6% at 85-100%, 1.9% to 4.7% at 70-85%, and 3.4% to 6.5% at 55-70% saturation. **DISCUSSION:** All four pulse oximeters demonstrated reduced precision as arterial O₂-saturation decreased, evidenced by increased LoA and RMSE values. According to RMSE values, three out of four pulse oximeters performed satisfactorily, showing lower variability than ISO recommendations (3%-points) in the 70-85% and 85-100% saturation intervals. However, below 70% saturation, all pulse oximeters exceeded the 3%-point RMSE threshold. This study highlights a decrease in the precision of pulse oximetry below the 70% O₂-saturation levels used for medical validation. These findings can be of value for researchers studying severe hypoxia and healthcare professionals involved in hypoxia recognition training for aircrews.

Learning Objectives

1. Are pulse-oximeters as accurate below 70% as above 70% saturation?
2. How low can the O₂ saturation fall during hypoxia familiarization training?

[237] USING CLOSED-LOOP MODELS TO UNDERSTAND MANUAL CONTROL ADAPTATIONS TO GRAVITATIONAL TRANSITIONS

Tara Nibhanupudy¹, Kassia Love², Marissa Rosenberg³, Raquel Galvan-Garza⁴, Torin Clark⁵, Faisal Karmali²

¹Massachusetts Eye and Ear; Boston University School of Medicine, Boston, MA, United States; ²Massachusetts Eye and Ear, Boston, MA, United States;

³SpaceX, Hawthorne, CA, United States; ⁴Lockheed Martin, Arlington, VA, United States; ⁵University of Colorado Boulder, Boulder, CO, United States

(Original Research)

INTRODUCTION: Humans control vehicles by continuously sensing orientation and motion, then making motor commands to the vehicle. Sensory feedback is altered in various situations, such as changes in G-level. While the brain has been shown to have a remarkable ability to adapt, in some situations, this is fundamentally limited. Furthermore, the mechanisms by which adaptation occurs are not completely understood. In this study, we used closed-loop models of human-vehicle systems to examine changes in strategy after a G-level transition. We hypothesize that transitioning to hypogravity leads to increased manual control variability secondary to vestibular signals of decreased amplitude, and post-transition adaptation is fundamentally limited by sensory signal-to-noise ratio (SNR). **METHODS:** Our model predictions use published data from a studied head-centered roll-tilt manual control task (Rosenberg et al, 2018). Healthy experimental subjects were recruited and screened via EMR and vestibular testing, with approval by local human studies committees at MEEI and MIT. Subjects ($n=10$, 27.9 ± 6.0 yr) aimed to maintain a perceived-upright position while experiencing passive, pseudorandom, head-centered roll-tilt perturbations in a centrifuge simulating a transition from 1G to a 0.5G. Model free parameters included bias and Kp (subject control effort). We characterized manual control performance using chair position variability. **RESULTS:** Subjects demonstrated a statistically significant increase in roll-tilt manual control variability when transitioning from the final 1G trial to the first 0.5G trial ($p < 0.001$). Variability slightly decreased over 6 successive 0.5G trials, with an associated increase in Kp. In the final 0.5G trial, subjects did not completely return to their baseline 1G performance variability

($p < 0.001$). **DISCUSSION:** Roll-tilt manual control becomes significantly more variable upon immediate transition from 1G to 0.5G. Some adaptation was observed, with modest improvement in manual control variability over repeated testing post-transition to hypogravity. Subject effort may contribute to this adaptation. Full adaptation to 1G performance quality may not be possible given diminished SNR in hypogravity, which has significant implications for Moon and Mars landings. Further study of manual control behavior during gravitational transitions will inform training protocols and/or countermeasures to facilitate adaptation and optimize performance.

Learning Objectives

1. Understand how roll-tilt manual control performance quality changes immediately after transition from 1 G to a novel 0.5 G environment.
2. Assess whether roll-tilt manual control performance quality has the potential to adapt over repeated trials in an altered gravity environment through changes in manual control strategy

[238] REVIEW OF AIRCRAFT CREW BREATHING SYSTEMS ALLOWABLE CHEMICALS

Christin Duran, Mitchell Rubenstein

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

WITHDRAWN

[239] HYPOXIA AND EXTENDED TIME ON TASK: EFFECTS ON DYNAMIC STEREOSCOPIC DEPTH TRACKING

Leonard Temme, Paul St Onge, Bobby Bowers, Kevin Andres, Aaron McAtee, Ryan Mackie
U.S. Army Aeromedical Research Laboratory, Fort Novosel, AL, United States

(Original Research)

INTRODUCTION: Army regulations permit aircrew of unpressurized aircraft to fly up to an altitude of 10,000 feet (ft) for an essentially unlimited duration without supplemental oxygen. The scientific literature documents the degradation of static stereo acuity (SSA) with hypoxia below 10,000 ft but is less clear about hypoxia effects on dynamic stereo acuity (DSA). Moreover, aircrew perform visually demanding, precise tasks for extended periods of time, which may be fatiguing and disruptive of binocularity when stereopsis is crucial, such as during formation flight, aerial refueling and so forth. This report describes a study of SSA and DSA in the presence of hypoxia and fatigue. **METHODS:** Reported here is a within-subject, repeated measures, two factor experiment with all subjects ($N = 24$) experiencing all conditions. One factor is the percent oxygen (O_2) of inspired air with two levels, normoxia (21% O_2) and a normobaric hypoxic approximation to a 10,000 ft altitude (14% O_2). The second factor is testing duration with four time periods, Epochs 1-4. Each Epoch included 10 minutes of a surrogate workload task, the Multi Attribute Task Battery (MATB) and 15 minutes of vision testing that included SSA and DSA measures for a total exposure duration of 108 minutes. The primary DSA results are reported as root mean square error (RMSE) arcseconds while the SSA results are stereoacuity in arcseconds. **RESULTS:** The distribution of DSA RMSE values was bimodal, with 8 subjects having RMSE values approximately 56% larger than the other 16 subjects. For both groups of subjects, hypoxia significantly increased ($p \leq 0.006$) the RMSE of DSA by about 7%. The group of 8 subjects with larger RMSE values showed an improvement (RMSE decreased) over testing Epochs, however, when hypoxic, this improvement reversed during the Epoch 4, suggesting the possible impact of fatigue combined with

hypoxia. Neither hypoxia nor test duration had a statistically significant effect on SSA. **DISCUSSION:** Importantly, SSA was not correlated with the DSA RMSE; performance on one task did not predict the other. For selection standards, one cannot be used as a surrogate of the other. Results are discussed in terms of physiological stressors.

Learning Objectives

1. To describe stereoscopic depth tracking as distinct from static stereopsis.
2. Describe the impact of hypoxia and the extended performance of a demanding task on these different types of depth perception.

Tuesday, 05/07/2024
Grand Hall K

4:00 PM

[S-44]: PANEL: RESIDENT IN AEROSPACE MEDICINE (RAM) GRAND ROUNDS III

Chair: Jonathan Elliot

Co-Chairs: Paul Newbold, David Miller

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

[240] WAVES OF ILLNESS: PSEUDO DECOMPRESSION SICKNESS IN AN ACTIVE DUTY NAVAL AVIATOR.

Gordon Salgado

Naval Aerospace Medical Institute, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: This case report describes the management of a Naval Aviator who experienced pressure fluctuations in the cockpit and later developed a constellation of symptoms concerning for decompression sickness. **BACKGROUND:** Loss of pressure at altitude poses risk of decompression sickness, a medical emergency rarely seen in aviation. The evaluation and management of decompression sickness is not widely known, or commonly practiced outside the dive medical community. **CASE PRESENTATION:** A previously healthy male Naval Aviator presented to evening sick call with concern for possible decompression sickness. He described symptomatic pressure fluctuations in the cockpit followed by the gradual development of generalized fatigue and malaise, headache, a mildly pruritic rash, myalgias and arthralgias with waxing and waning neuropathic symptoms in the right lower extremity. An Undersea Medical Officer was consulted. A quick calculation revealed the pressure changes posed no risk. The pilot was reassured, and provided with a variety of palliative measures. On serial follow up, all symptoms resolved confirming multiple etiologies occurring concurrently. **DISCUSSION:** This case highlights the import of familiarity with decompression sickness, reiterates the pathophysiology and management of this rare medical emergency, proposes the calculation of pressure differential exposure as a clinical decision making tool, and restates the value of a broad differential.

Learning Objectives

1. The audience will learn about the pathophysiology of decompression sickness.
2. The audience will learn about the presentation and clinical assessment of decompression sickness.

3. The audience will learn a valuable clinical decision making tool for the triage of potential decompression sickness cases.

[241] HIDING IN PLAIN SIGHT: ASYMPTOMATIC COATS' DISEASE IN AN AIRCREW CANDIDATE

Alexander Haley, David Tindle

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case report describes an aircrew candidate found on initial aircrew screening to have Coats' disease, despite lacking symptoms, and subsequently recommended for disqualification from all flying duties due to unacceptable aeromedical risk. **BACKGROUND:** Coats' disease is a sporadic, congenital, nonhereditary ocular disease characterized by retinal telangiectasis leading to exudative retinopathy and detachment. Coats' disease is very rare, with an incidence of 0.9 per 100,000 and prevalence estimated at fewer than 200,000 individuals in the United States. It exhibits a bimodal distribution with peaks in young males under 4 and males in their 50s. Younger age at presentation typically correlates with increased disease severity. **CASE PRESENTATION:** During routine initial ophthalmologic screening at the U.S. Air Force School of Aerospace Medicine's Medical Flight Standards, the candidate was found to be plano sphere both eyes with uncorrected distant and visual acuity of 20/20 both eyes. The candidate had no history of ocular symptoms, retinal detachment, or ocular surgery. However, his right eye was noted on ophthalmoscopy to have a moderate-sized area of distal arterial beading and retinal blot hemorrhages in the temporal periphery without exudates, retinal detachment, or vitreoretinal traction. The Aeromedical Consultation Service confirmed these findings, and the candidate was referred to a civilian retinal specialist who confirmed the diagnosis of Coat's disease. An aeromedical waiver was not recommended, and the candidate was disqualified from all flight duties. **DISCUSSION:** Coats' disease is aeromedically significant due to high risk of sudden incapacitating visual loss from retinal detachment. Other ocular concerns include widespread exudation even away from the area of telangiectasia with a predilection for the macula, ischemia of the retina in areas of telangiectasia, and intra- and subretinal hemorrhage. These events can lead to degraded stereopsis, decreased contrast sensitivity, visual field loss, and permanent vision loss. Critically, only 12% of patients maintain better than 20/50 vision long-term. While the disease is rare, it can be missed without rigorous screening, since affected aircrew candidates may be asymptomatic with normal visual acuity. This case highlights the importance of robust ophthalmologic aircrew screening and physician awareness of this disease entity and its aeromedical risks.

Learning Objectives

1. Gain awareness and understanding of the typical demographics, presentation, and symptoms of Coats' disease, the aeromedical risks associated with even mild or asymptomatic cases, and the importance of robust ophthalmologic screening for aircrew candidates.
2. Apply understanding of pathology and features of Coats' disease and its aeromedical risks to current aeromedical certification standards from civil and military aviation organizations to optimize aeromedical disposition of individuals with Coats' disease.

[242] DOUBLE URETERAL TROUBLE: A CASE REPORT ASSESSING THE AERONAUTICAL RISK OF CONGENITAL DUPLICATION OF THE RENAL COLLECTING SYSTEM

Patrick Edwards, Shana Hirschert

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case report describes a high-performance pilot-in-training with a duplicate renal collecting system and severe hydroureteronephrosis. **BACKGROUND:** Complete or partial duplication

of the renal collecting duct, is the most common congenital anomaly of the urinary tract with a prevalence of 0.8 to 5.0%. This anomaly is thought to be duplication of the ureteric bud in utero with one ureter connected to the upper pole of the kidney and the other with the lower pole. Duplication can be partial or complete, but partial is more common. Most cases remain asymptomatic. Specialist evaluation is required if there is evidence of obstruction or infection. **CASE PRESENTATION:** A 31-yr-old male high-performance student pilot was seen for flank pain in the emergency department and discharged. A computed tomography identified a right duplicated renal collecting system with severe hydroureteronephrosis of the upper pole and calcifications. Urology performed a cystoscopy, showing that the upper collecting duct did not insert distally and that the calcifications likely would not pass. A computed tomography urogram and Lasix renal scan showed the duplication was complete, patent and insertion of the upper pole ureter was inferomedial to the lower pole insertion. The Aeromedical Consult Service reviewed the case, and a waiver for non-high-performance Flying Class (FC) IIC was granted. Later, elective removal of the right superior renal moiety and collection system resulted in an unrestricted FC II waiver, with intraoperative findings clarifying the upper pole insertion to be in the prostatic urethra. **DISCUSSION:** This patient had two prior episodes of flank pain evaluated and released from the emergency department but had never had flight surgeon follow-up. Testing concluded that the atrophic right upper pole moiety only contributed 8.2% of total renal function. The primary aeromedical concern is the intermittent and debilitating pain during critical phases of flight. The treating nephrologist considered the partial nephrectomy adequate mitigation of this risk. After surgery and recovery, the case was reevaluated and the Aeromedical Consult Service granted an unrestricted FC II waiver, allowing return to high-performance training.

The views expressed are those of the authors and do not reflect the official guidance or position of the U.S. Government, the Department of Defense, the U.S. Air Force, the U.S. Space Force, the Canadian Government, or the CAF.

Learning Objectives

1. Understand the prevalence of duplex kidney in the general population and how this condition might present.
2. List the safety of flight concerns that exist because of a duplex kidney.
3. Understand the complications that can arise but may be asymptomatic in this condition.

[243] CRACKING SKULLS TO GET A WAIVER: CASE REPORT

Casey Naumoff, Dane Newell

USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case describes an aviator with a skull fracture and the process to an unrestricted Flying Class (FC) II waiver. **BACKGROUND:** Traumatic brain injury (TBI) is prevalent with an annual incidence around 2.5 million in the United States. TBIs carry an elevated seizure risk at different stages following injury as well as functional and neurological deficits. Following a mild TBI, relative risk of seizures remains elevated for five years and ten years in moderate to severe TBIs compared to the normal population. **Case Presentation:** A 30-yr-old male pilot sustained a non-displaced basilar skull fracture after slipping and falling on bathroom floor. There was no LOC, or any immediate neurological symptoms. The following morning, spouse noticed bruising around eyes and insisted a visit to the Emergency Room. Non-contrast head CT showed a non-displaced basilar skull fracture, with no other concerning findings and continued to deny symptoms. Neurological evaluation two months later and follow up MRI brain was normal. Due to mild nature of injury without neurological symptoms, waiver was submitted at month 4 prior to the required 6-month waiting period. An FC IIC restricted waiver

for non-high performance, dual-piloted aircraft with another qualified pilot present during aircraft operations was approved 5 months post injury. Waiver renewal at 12 months was accomplished and an indefinite unrestricted FC II waiver was approved, and the pilot is now a T-6 instructor pilot where he continued to have no symptoms or neurological deficits. **DISCUSSION:** This case emphasizes the importance of why TBIs require mandatory grounding wait periods, depending on severity, and the elevated risk to the flight environment. Prompt identification and advocating for the aircrew member to obtain a waiver as soon as practical is an important aspect to consider with every case. This case highlights the importance for both aviators and flight surgeons understanding of TBI seizure risks.

Disclaimer: The views expressed are those of the authors and do not reflect the official guidance or position of the U.S. Government, the Department of Defense, or the U.S. Air Force.

Learning Objectives

1. Describe the aeromedical concerns following TBI, appropriate observation timelines for the military aviator, and timeline for return to baseline risk for seizure occurrence.
2. Describe the Federal Aviation Administration processes for special issuance (SI) in the civilian aviator.

[244] MONOARTICULAR RHEUMATOID ARTHRITIS IN A USMC AIRCREW MEMBER

Kristopher Randall

Naval Aerospace Medical Institute, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: This case report describes a USMC aircrew member with a rare presentation of rheumatoid arthritis (RA).

BACKGROUND: Rheumatoid arthritis is a systemic, inflammatory, autoimmune, polyarthritis characterized by persistent synovitis, systemic inflammation, and autoantibodies. RA can affect any joint but is usually found in the interphalangeal joints and occasionally in the wrist, knees, and spine. Monoarticular variant RA is an uncommon presentation and presentation in the elbow is exceedingly rare. If left untreated, RA will have progressive inflammatory cartilage breakdown, joint deformity, stiffness, and pain. **CASE PRESENTATION:** This case report describes a 21-year-old female USMC Aircrew member with a few months of atraumatic right elbow pain. Initial exam was unremarkable and x-ray imaging was negative. The patient was prescribed a typical conservative treatment course but returned with complaints of worsening pain and restricted range of motion. An MRI was obtained and showed near complete cartilage loss as well as associated joint effusion and synovitis. Inflammatory arthritis work-up showed positive rheumatoid factor (366 IU/ml) and positive anti-CCP antibody assay (144 u/ml). The patient was diagnosed with monoarticular variant RA, underwent orthopedic synovectomy surgery for symptom management, and started disease modifying anti-rheumatic (DMARD) therapy with methotrexate. **DISCUSSION:** This case highlights an exceedingly rare presentation of an autoimmune arthritis that can lead to lifelong disability if left untreated. There are numerous aeromedical risks with this condition and can occur as a result of the disease itself and/or as treatment side effects. Progressive joint deformity and range of motion loss can impair flight performance. Joint instability, especially atlantoaxial instability seen in spinal RA, poses hazards with high performance aircraft and G-force stresses. Side effects associated with the common DMARD methotrexate, including ataxia and pneumonitis, are not acceptable in the aviation environment. Aeromedical standards for return to flight status varies by agency. RA is a CACI condition for asymptomatic patients well controlled on medication(s) while the Navy may rarely grant a waiver on a case-by-case basis. Early recognition and treatment of RA is essential to prevent disease progression and increase the chance for an aviator to return to a flying status.

Learning Objectives

1. Understand the presentation, diagnosis, and treatment of rheumatoid arthritis including typical and atypical presentations.

2. Discuss the aeromedical implications of rheumatoid arthritis as well as aeromedical standards for flight status of civilian and military agencies.

[245] RARE GENETIC MUTATION IN PRESENTATION OF PORTAL VEIN THROMBOSIS

Edwin Manley

Naval Aerospace Medical Institute, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: This case report describes the presentation of a Marine Corps Aviator who presented with an acute portal vein thrombosis. **BACKGROUND:** Venous thromboses are not necessarily uncommon findings in aviators, especially if certain conditions predispose, such as long periods of venous stasis. However, presentations of splanchnic vein thromboses are much more rare, and usually in settings of underlying liver pathology, mainly cirrhosis or acute liver failure. Far less common is the genetic mutation of JAK2, especially in a setting where there does not appear to be a concomitant myelodysplastic syndrome. **Case Presentation:** An experienced 40-year-old Marine Aviator presented to his Flight Surgeon with acute low-grade left upper quadrant pain. While initially thought to be upper GI related in etiology, a conservative course of observation and treatment for dyspepsia was prescribed. During this time, the patient presented to a local emergency department with a severe exacerbation of pain. A subsequent CT scan demonstrated a large portal vein thrombosis with associated splenomegaly. Initial differential diagnosis included the possibility of cirrhosis secondary to alcohol abuse. While this may be the most common cause of acute PVT, it did not fit with the patient's history. A subsequent hematology workup revealed a rare JAK2 mutation that would predispose to splanchnic vein thromboses. At this time, the patient has been placed on chronic anticoagulation and will require further work up for myelodysplastic syndrome. **DISCUSSION:** At the most basic level, this case highlights the presence of venous thrombosis in aviators requiring chronic anticoagulation. Although the treatment aims at preventing a catastrophic propagation and migration of the clot to the pulmonary system, the underlying etiology of this aviator's presentation may pose further implications into their health and flying status given the concern for development of a chronic hematologic syndrome.

Colaizzo, D *et al* (2006). The JAK2 V617F mutation frequently occurs in patients with portal and mesenteric venous thrombosis. *J Thromb Haemost.* 2007 Jan;5(1):55-61.

Kiladjian, J *et al* (2008). The impact of JAK2 and MPL mutations on diagnosis and prognosis of splanchnic vein thrombosis: a report of 241 cases. *Blood* Vol 111, Issue 10

Learning Objectives

1. The participant will be able to understand uncommon genetic mutations that involve presentations of venous thrombosis.
2. The audience will be able to understand the common, and not so common, etiologies specific to portal and splanchnic vein thrombosis.
3. The participant will be able to understand myelodysplastic syndromes.

Tuesday, 05/07/2024

Grand Hall GH

4:00 PM

[S-45]: PANEL: APPLICATIONS OF ARTIFICIAL INTELLIGENCE (AI) TO COMBAT AVIATION MISHAPS

Chair: Merrill Rice

PANEL OVERVIEW: BODY: The applications for AI regarding Aerospace Medicine are broad and have the potential to dramatically improve safety

by recognizing hazards and preconditions that may predispose aviators to mishaps. Some of the ways AI may assist aviators in the cockpit include predictive analysis, machine learning for pilot training, data analysis, sensor fusion, real-time monitoring, alert systems, and accident investigation. The panel will provide an overview of the existing research that has utilized AI in extreme environments. The authors will further propose a framework by which investigators may follow to identify cognitive performance decrements from common aeromedical hazards such as hypoxia, spatial disorientation, and fatigue and transition the technology to the operational environment. The second presentation of this panel will describe generally employed computer programs such as principal component analysis (PCA) to "clean" data and reduce variance, effectively transforming data so that it may be utilized effectively by AI. The third presentation will be a description of how commonly employed AI algorithms such as decision tree, Naïve-Bayes, and Neuronet can be utilized in conjunction with PCA to increase sensitivity and specificity in identifying notable aviation hazards of concern. Finally, the panel will describe AI techniques to analyze recent aviation mishaps to more reliably identify human factors that are associated for preventing future aviation mishaps.

[246] A METHODOLOGY FOR USING ARTIFICIAL INTELLIGENCE (AI) TO IDENTIFY COGNITIVE PERFORMANCE DECREMENTS IN AVIATION OPERATIONAL ENVIRONMENTS

G. Merrill Rice¹, Dallas Snider², Steve Linnville³

¹Naval Safety Command, Norfolk, VA, United States; ²University of West Florida, Pensacola, FL, United States; ³Naval Aerospace Medicine Research Laboratory-Dayton, Dayton, OH, United States

(Education - Program/Process Review)

BACKGROUND: The applications for AI regarding aerospace medicine are broad and have the potential to dramatically improve safety by recognizing hazards and preconditions that may predispose aviators to mishaps. How may aeromedical researchers leverage this emerging technology to combat the most common human pre-conditions that contribute to aviation mishaps? **OVERVIEW:** Upon review of the cited human pre-conditions involved in naval aviation mishaps between 2012 to 2022, some of the most common contributing pre-conditions involved were fatigue, spatial disorientation, visual illusions, hypoxia and hyperventilation. Recently, both fatigue and spatial disorientation have been evaluated in simulated aviation environments with semi-dry and dry EEG systems. Lee et al. (2023), utilized a semi-dry 30 channel head-set, during simulated flight and were able to identify abnormal mental states, such as fatigue, high workload and distraction, finding 9 EEG indices that were significantly different with varied flight tasks. Likewise, Geva, et al. (2023), utilized a 32 channel dry-EEG, during Barani chair induced spatial disorientation and noted a 52% reduction in theta power complemented by nystagmus in 72% of the trials. What was lacking in both studies, as demonstrated by relatively low accuracy was a method of cleaning their EEG data and reducing the variance within specific bandwidths. Realizing the need for real-time sensors on cognitive performance in military aviation, Rice (2019) evaluated dry-electroencephalogram (EEG) technology ability to detect hypoxia. Their research suggested that a reduction in overall dry-EEG power could identify hypoxia in lieu of aviators not recognizing their own meaningful decreases in oxygen saturation and cognitive performance. Linnville (2021) and Snider (2022) respectively advanced this work further by reducing the variance of the data sets through principal component analysis (PCA) and then applying three common AI algorithms. By doing so, these researchers increased the sensitivity and specificity of dry-EEG technology to detect hypoxia to greater than 97%. **DISCUSSION:** This presentation will provide a framework for future researchers to investigate and mitigate the most commonly associated preconditions for

aviation mishaps with AI. The ultimate goal being to provide the aviator a useful real-time, helmet embedded sensor to prevent mishaps in our next generation aircraft.

Learning Objectives

1. The participant will be able to identify the common pre-conditions associated with aviation mishaps that may potentially be identifiable through the acquisition of data obtained through multi-dimensional biosensors such as electroencephalogram (EEG) and electrocardiogram (ECG) and subsequently analyzed utilizing artificial intelligence algorithms.
2. The participant will understand broadly common computer programs and artificial intelligence algorithms to clean and produce models that accurately predict and identify common human preconditions that are associated with aircraft mishaps.

[247] PRINCIPAL COMPONENT ANALYSIS (PCA) A METHODOLOGY FOR "CLEANING" MULTIDIMENSIONAL TIME SERIES BIODATA FOR ARTIFICIAL INTELLIGENCE (AI) MODELING

Steven Linnville

Naval Medical Research Unit-Dayton (satellite office), Pensacola, FL, United States

(Education - Program/Process Review)

BACKGROUND: In 2010, the Naval Safety Command identified between 1990 and 2008 fatigue was the leading cause of mishaps and hazard reports (n=150), and spatial disorientation as the second leading cause of mishaps (n = 78). Years later, the Command, repeated the analysis and fatigue (n=159) and spatial disorientation (n=90) continued to be the top 2 leading mishap causes between 2011 and 2018. This 40-year history points to a need to monitor a pilot's performance closely while in flight. Current crash avoidance systems in the cockpit monitor a plane's performance but not a pilot's. A variety of time series biodata (e.g., electroencephalogram [EEG], electrocardiogram, galvanic skin response, blood oxygen saturation, & eye movements) can be recorded indexing multidimensional sensory input and "interpreted" mathematically in machine learning as a biofeedback alert system to the pilot. This presentation discusses a method to simplify such input for AI use.

OVERVIEW: Time series data can be multidimensional and difficult to analyze and interpret. To simplify the data, a dimension reduction procedure can be performed. One way is the application of PCA. This presentation will describe in "layman" terms theory and methodology behind the use of PCA and will be part of a panel that will provide an overview of the use of AI in extreme environments. This discussion will propose a framework by which investigators may follow to clean and interpret physiological measures that could impact cognitive performance in common aeromedical hazards (hypoxia, spatial disorientation, and fatigue) to transition this technology to the operational environment. The discussion of PCA will be based on dry-EEG data to reliably detect hypoxia in the lab with the goal such application could be used with any multidimensional biodata for AI input and use. **DISCUSSION:** Presently, there is an absence of strategies other than pharmacological methods (caffeine or amphetamines) to maintain pilot performance in extreme environments. This presentation is a step into aviation preventive measures with the eventual goal of pilots wearing sensors with live data streaming into real time AI use.

Learning Objectives

1. The audience will learn a user-friendly understanding of how to identify the most important features in their data for further analysis into machine learning.
2. The audience will learn that the data excluded simplifies the data while not losing the most important features for further analysis into machine learning.

[248] A THEORETICAL ASSESSMENT OF THE USE OF GENERATIVE ARTIFICIAL INTELLIGENCE TO AUTOMATICALLY CATEGORIZE MISHAP REPORT DATA

Jefferson Grubb

Naval Safety Command, Norfolk, VA, United States

(Education - Program/Process Review)

BACKGROUND: Mishap investigators compile their findings into reports so that others can avoid factors that led to previous mishaps. The narrative portions of these reports provide detailed information about what happened in individual mishaps. However, for safety professionals to track trends and assess hazards across multiple mishaps, these narrative data must first be summarized according to categorical coding systems. Within the U.S. Department of Defense (DoD), investigators from different Services receive different training, operate under different reporting instructions, and report using different business rules. These differences reduce the reliability with which investigators assign standardized codes, such as those of the Department of Defense Human Factors Analysis and Classification System (DoD HFACS). Moreover, periodic changes to DoD coding systems further degrade the longitudinal comparability of such coded data. These factors interfere with the DoD's ability to use mishap data to prevent future mishaps. **OVERVIEW:** Natural language processing facilitated by Large Language Models (LLMs), a type of generative artificial intelligence, may provide a logistically feasible, standardized way to categorically analyze mishap narratives. Such models are trained on large corpora of written materials and are subsequently more able to semantically assess target texts than are other approaches to natural language processing. In this presentation, the author examines both the technical and non-technical feasibility of two potential uses of LLMs to analyze human factors contributions to mishaps. First, can LLMs automatically code mishap narratives according to DoD HFACS? Second, can LLMs answer requests for human factors information independent of DoD HFACS coding? **DISCUSSION:** Although both use cases may be technically feasible, each use case faces a host of programmatic and cultural hurdles. The author argues that in the long-run, the second use case has more utility. However, it will be easier to overcome the non-technical hurdles in the first use case. The DoD should therefore explore a phased approach in which LLMs are initially used to apply DoD HFACS codes to mishap narratives. If successful, safety professionals can use the resulting models and infrastructure to explore using LLMs to categorize mishap narratives according to terms that are specific to individual information requests.

Learning Objectives

1. Recognize the limitations of categorically coded data in Department of Defense mishap reports.
2. Understand how large language models can be used to mitigate some limitations of categorically coded data in Department of Defense mishap reports.

[249] AI 101 FOR THE AEROSPACE MEDICINE SPECIALIST

Dallas Snider

University of West Florida, Pensacola, FL, United States

(Education - Program/Process Review)

BACKGROUND: Since 2014, researchers at Naval Air Station Pensacola have evaluated the feasibility of using commercial-off-the-shelf wearable sensors for monitoring the health of aviators in-flight. With each successive study, the complexity of the sensors used, and the physiological measurements have increased. Studies have examined heart rate, g-forces, the effect of hypoxia on brain waves, and cognitive performance utilizing wearable sensor data. With advances in wearable sensors and their data collection and processing software, the researchers are investigating the ability to detect fatigue and spatial disorientation (SD), which have been the top two leading causes of aviation mishaps since 1990. The aviation industry is behind in developing pilot performance monitoring

compared to the automobile industry's driver performance monitoring. The latter has developed algorithms to detect driver fatigue and lane departures using on-board sensor suites with communication channels open to the public and access to cloud-based artificial intelligence (AI). However, systems to prevent human-induced aviation mishaps in tactical aircraft will require self-reliant technology that with smaller volume and weight. **OVERVIEW:** Machine learning (ML) is the foundation of AI. There are various ML algorithms, each with their own pros and cons. Some algorithms work well for controlled clinical trials, but not well in a real-time environment. To build a system that can detect physiological hazards such as fatigue, cognitive impairment, and SD, multiple sensors and the proper ML algorithms will be required. The disparate sensor data needs to be cleaned, fused, and input into the ML algorithms to train individualized, multidimensional models optimized for each pilot. In flight, the collected data needs to be processed and classified in real-time to determine if the pilot is in danger. **DISCUSSION:** While the capabilities of AI and deep learning are receiving attention in news, advertising, and social media; cloud-based AI solutions are not feasible in a tactical fighter jet. Any AI solution must be self-contained within the sensor system. In this presentation, we will present a primer on ML and AI, separate fact from fiction about what is currently feasible in ML and AI, and what could be possible in a few years.

Learning Objectives

1. The participant will be able to explain which machine learning algorithms are best suited for real-time, artificial intelligence applications.
2. The participant will be able to explain the knowledge discovery in data process.

Tuesday, 05/07/2024

Grand Hall I

4:00 PM

[S-46]: SLIDES: ASTRONAUT GAS ISSUES

Chair: Kathleen Samoil

Co-Chairs: Tom Hoffman

[250] RISK OF AIR GAS EMBOLISM WITH LOW PRESSURE DIFFERENTIALS IN SPACEFLIGHT

Craig J. Kutz, Amy J. Kreykes, Rebecca Blue

UTMB, Galveston, TX, United States

(Original Research)

INTRODUCTION: As the focus of space exploration evolves to include longer duration missions, more extensive extravehicular activity (EVA) capabilities and variable intravehicular environments will be required. An abrupt ambient pressure change with a closed glottis poses well-documented risk in diving literature for pulmonary overinflation syndrome and air gas embolism (AGE), conditions that can propagate to permanent disability or death. Variable pressure changes are not insignificant, and injury can occur even at low-pressure differentials and rapid closed-system volume variations. The exact minimum pressure threshold posing risk, however, is not clearly defined. The goal of this study was to review current literature and collate minimum pressure changes placing astronauts at risk for barotrauma during space operations. **METHODS:** A literature review of published research and case reports was conducted to gather data related to low ambient pressure changes resulting in pulmonary barotrauma or AGE. 124 publications were reviewed for relevance. Pressure differentials in operational space environments were extrapolated to characterize risk for conditions leading to theoretical alveolar rupture. **RESULTS:** Twenty cases of human barotrauma due to ambient pressure changes below 5.0 psid were identified, with 7 cases below 2.0 psid, or the equivalent of diving below 4 feet of saltwater (fsw). An AGE diagnosis comprised 85% of the

cases, including 3 fatalities. Six animal studies and one cadaver study were also identified as contributing to mathematical modeling of alveolar tissue limits in transpulmonary pressure. **DISCUSSION:** Severe decompression barotrauma, such as AGE, poses a substantial risk to crew and mission safety, as intravascular bubbles can lead to significant disability, or death. The delta pressures identified in the literature reviewed are highly relevant to space operations, in both EVA and intravehicular environments. Given the high consequences and difficulty in treating disabling decompression injuries during a mission, mitigation via robust vehicle and suit design remains the best strategy for risk reduction. The results identified theoretical, experimental, and observational parameters for delta pressure variables of concern that may be referenced to identify the risk of barotrauma for crew safety and mission success.

Learning Objectives

1. The audience will understand the significance of lower pressure changes in space operations as they relate to the risk of air gas embolism and pulmonary overinflation barotrauma.
2. Audience members will learn about published literature and case reports on theoretical, experimental, and observational parameters for delta pressure variables reported in barotrauma.
3. The audience will understand the implications and risk of barotrauma in space operations for crew safety and mission success.

[251] CARDIOVASCULAR DOSE-RESPONSES TO LOWER BODY NEGATIVE PRESSURE AND IMPLICATIONS FOR COUNTERMEASURE DESIGN

Ana Diaz-Artiles¹, Richard S. Whittle²

¹Texas A&M University, College Station, TX, United States; ²University of California, Davis, Davis, CA, United States

(Original Research)

INTRODUCTION: Lower body negative pressure has been posited as a long-duration countermeasure to reverse the fluid shift caused by the removal of hydrostatic pressure gradients in microgravity. Both the risk of spaceflight associated neuro-ocular syndrome (SANS) and the concern of venous thromboembolism (VTE) are believed to be related to this fluid shift. The aim of this study was to generate dose-response curves for the cardiovascular system when subjected to graded LBNP, then use the curves to quantify LBNP's potential as a countermeasure to reverse the effects of a cephalad fluid shift. **METHODS:** Twenty-four subjects (12M, 12F, age 28.5±4.7 years, height 169.6±12.0 cm, weight 74.5±21.0 kg) were exposed to LBNP from 0 mmHg to -50 mmHg (in 10 mmHg increments) in supine and 15° head-down tilt (HDT) postures. Dose-response curves of systemic cardiovascular variables, autonomic indices, and cephalad parameters including intraocular pressure (IOP), ocular perfusion pressure (OPP) and IJV flow pattern were constructed using Bayesian multivariate hierarchical modeling. **RESULTS:** All measured parameters exhibited a linear response to LBNP across the range measured. The largest positive effect sizes were found in the increase in total peripheral resistance and myocardial oxygen supply:demand index with increasing negative pressure. The largest negative effect sizes were found in the decrease in cardiac and stroke index with increasing negative pressure. In contrast, parameters related to the head and neck (IJV cross sectional area and pressure, IOP) were the variables most influenced by the cephalad fluid shift caused by 15° HDT. Dose-response curves for supine and HDT were combined to estimate the LBNP required to reverse a fluid shift induced by 15° HDT. **DISCUSSION:** Systemic cardiovascular parameters and autonomic indices require a range between -3.7 mmHg to -14.3 mmHg to reverse the effect of a fluid shift induced by 15° HDT. Parameters related to the head and neck require a higher LBNP between -14.7 mmHg (IJV flow pattern) to -45.5 mmHg (IJV cross-sectional area) to reverse the same fluid shift. LBNP appears to reduce IOP but not OPP. LBNP may help to reverse microgravity-induced IJV flow stagnation but its application in the context of SANS require further investigation.

Learning Objectives

1. The audience will understand the quantitative effects of LBNP on all aspects of the cardiovascular system.
2. The audience will understand the potential implications of these dose-response curves with respect to LBNP as a spaceflight countermeasure.

[252] SURVEILLANCE FOR JUGULAR VENOUS THROMBOSIS IN LONG-DURATION SPACE FLIGHT: FINDINGS FROM TWENTY-EIGHT U.S. ASTRONAUTS

Ashot Sargsyan¹, James Pavela², Aaron Everson¹, Deepak Bedi³

¹KBR, Houston, TX, United States; ²NASA JSC, Houston, TX, United States;

³University of Texas MD Anderson Cancer Center, Houston, TX, United States

(Original Research)

BACKGROUND: Given the high incidence of internal jugular vein (IJV) flow anomalies aboard the International Space Station and a case of thrombosis, the National Aeronautics and Space Administration (NASA) instituted an occupational surveillance program to evaluate astronauts for venous thromboembolism (VTE). Current findings of the program are presented. **METHODS:** NASA astronauts undergo pre- and in-flight VTE surveillance examinations using a standardized vascular ultrasound protocol, which includes evaluation for bilateral IJV compressibility, filling, flow, and spontaneous echo contrast (SEC). **RESULTS:** Twenty-eight NASA astronauts had terrestrial baseline examinations and at least one in-flight imaging session. The reduction of in-flight peak IJV flow-speeds was significant and more pronounced on the left. Comparing the first in-flight measurement to the terrestrial baseline, peak flow speeds were reduced from 90.1±41.9 cm/s (average ±SD) to 62.1±31.6 cm/s on the right and from 76.9±41.8 cm/s to 26.8±18.2 cm/s on the left. Seven astronauts showed stagnant or retrograde flow in the left IJV. Fourteen developed appreciable SEC in the left IJV (7 greater than mild); none developed significant right-sided SEC. All IJVs were fully compressible and free from thrombi. **DISCUSSION:** Bilateral IJV flow speed reduction is observed in microgravity, possibly due to the multitude of available flow redistribution paths for cranial drainage. In a subset of astronauts, significant flow anomalies develop that may facilitate thrombus formation through changes in blood viscosity and speed, especially if combined with other thrombogenic factors. These findings warrant attention to the interplay between individual vascular configurations and the dynamic properties of blood as a non-Newtonian fluid in the reduced-shear flow environment of microgravity.

Learning Objectives

1. The audience will learn about the published evidence supporting surveillance for venous thromboembolism (VTE) in International Space Station (ISS) astronauts.
2. The participants will learn about the methodology, schedule, and current findings of the VTE surveillance in ISS U.S. crewmembers.
3. The participants will learn about the essence and role of the non-Newtonian properties of blood in venous hemodynamics.

[253] QUANTIFYING THE RISK OF VENOUS AIR EMBOLISM FROM IV FLUIDS IN MICROGRAVITY AND ASSESSING THE STABILITY OF AIRLESS IV BAGS FOR EXPLORATION MISSIONS

Christiaan van Nispen¹, Jasmine Jaramillo², Michael Rubal², Craig Nowadly³

¹Brooke Army Medical Center, San Antonio, TX, United States; ²Southwest Research Institute, San Antonio, TX, United States; ³59th Medical Wing/ Brooke Army Medical Center, San Antonio, TX, United States

(Original Research)

INTRODUCTION: Commercial off-the-shelf (COTS) intravenous fluids (IVFs) bags contain residual air, introducing the risk of venous air embolism (VAE). VAE occurs when air displaces blood flow in vasculature.

The danger from residual air is often negligible in terrestrial settings, where gravitational forces generate buoyancy, pushing residual air to the top of the IVF bag. However, in microgravity there is no buoyancy to separate liquid and gas layers. We performed an experiment to quantify the amount of air in COTS IVFs (Experiment #1) and assess air removal as a risk mitigation strategy (Experiment #2). **METHODS:** Experiment #1: Residual air was quantified across varying volumes (100, 250, 500, and 1000 mL), bag design, and manufacture (B Braun, Baxter, ICU Medical, and Grifols) of 0.9% NaCl COTS IVFs. Experiment #2: 1000 mL 0.9% NaCl bags, from three manufactures, were filled with either A) 100% saline or B) 95% saline and 5% air by volume. Bags were stored for 84 days at 25°C or 40°C. The bags were optically imaged to determine if air bubbles evolved within the solutions. **RESULTS:** Experiment #1: There was a trend towards greater residual air in larger bag sizes ($R^2 = 0.465$). The smallest air:volume ratio occurred in the Baxter 500 mL VIAFLO® Container (18.9 ± 3.8 mL air; 2.3% air by volume), while the largest ratio occurred in the B Braun 250 mL EXCEL® Container (55.0 ± 9.3 mL; 22.0% air by volume). Experiment #2: By day 84, 97% (33/34) of experimental bags had an increase in air compared to baseline. Bags placed in 40°C had a larger increase in air (14.19 ± 4.75 mL) compared to 25°C (3.09 ± 3.56 mL; $p < 0.001$). **DISCUSSION:** Residual air has a wide variety of volumes in COTS IVFs. The average amount of residual air is high enough to contribute to clinically significant VAEs. If airless IV bags are produced for exploration missions, a progressive increase in the amount of residual air should be expected. Simple strategies can be taken to limit the risk of VAE during spaceflight.

Learning Objectives

1. Understand the impact of COTS IVF bag size and manufacturer on the air:volume ratio of residual air.
2. Understand the impacts of temperature and COTS IVF bag manufacturer on re-accumulation of residual air after production of airless bags.
3. Understand the implications of residual air and airless bag production on exploration space missions.

[254] UNDERSTANDING THE RELATION BETWEEN INTRACRANIAL PRESSURE AND SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME (SANS)

Gabriela Alves Rodrigues, Thais Russomano, Edson Santos Oliveira

CEMA (Center for Aerospace Medicine Studies), Lisbon School of Medicine, University of Lisbon, Lisbon, Portugal

(Original Research)

INTRODUCTION: Since 2011, neuro-ocular findings, such as globe flattening, optic disc edema or choroidal and retinal folds, have been one of the major concerns when talking about astronauts' health. These findings are, nowadays, called Spaceflight Associated Neuro-Ocular Syndrome (SANS). This systematic review aims to discuss the possible mechanisms involved on SANS' pathogenesis, such as intracranial pressure (ICP) variation, cerebrospinal fluid (CSF) compartmentalization and environment influence. We hypothesize that there is a relation between the variation of ICP and SANS development. Therefore, the question we want to answer is "Is the variation of ICP in astronauts who undergo long-duration spaceflights related to the development of SANS?". **METHODS:** This systematic review was structured according to PRISMA 2020 checklist and based on the PICO method. The search was conducted in five databases, Pubmed, Web of Science, Scopus, Google Scholar and Wiley Online Library. The 852 results were then imported to RAYYAN for duplicate removal. Based on the eligibility criteria previously defined, two reviewers, independently and with blinding, screened the remaining 738 results, and together, after a final discussion, chose 240 results to be fully analyzed. The ones that didn't make a relation between the findings and SANS and/or ICP were excluded. To assess the risk of bias, each included study was evaluated, with specific tools, according to the type of study. **RESULTS:** Twenty studies were reviewed. Nine establish a relation

between the variation of ICP (increase, reduction or both) and SANS. Seven explain the existence of CSF compartmentalization after LDSF/analogs, where four defend that the glymphatic system is the responsible for this mechanism. Additionally, five correlate hypercapnia and/or exercise with SANS, while one suggests a direct association with intracranial venous congestion. Finally, one explores astronauts' genetics. **DISCUSSION:** We believe that the studied theories are not mutually exclusive and that SANS has a multifactorial etiology, where ICP variation and its relation with CSF shifts, CSF compartmentalization and environmental factors have an important influence on the development of neuro-ocular changes. Despite some limitations, this work gives an interesting view on the development of this syndrome and it is a step forward to better understand it.

Learning Objectives

1. This systematic review contributes to the understanding of SANS multifactorial pathophysiology.
2. It is essential to find new diagnostic tools to use in astronauts and better understand SANS pathophysiology.

[255] MODELING THE INFLUENCE OF ALTERED-GRAVITY AND ORTHOSTATIC STRESS ON THE CARDIOVASCULAR SYSTEM

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(Original Research)

INTRODUCTION: Computational modeling techniques allow us to expand beyond the limits imposed by human experimentation. Lumped-parameter models of the cardiovascular system can be used to simulate the effects of altered-gravity environments and therefore, to make predictions on the risk of orthostatic intolerance, the efficacy of countermeasures, and the variation in responses elicited by different individuals. **METHODS:** In this study, we extended an existing 21-compartment lumped parameter model to incorporate a more detailed simulation of blood circulation in the head and neck. Further, we adapted the model to account for hydrostatic gradients caused by body tissue weight. We used this model to simulate four different altered-gravity conditions on 50th percentile male and female subjects: tilt (head-up and head-down), lower body negative pressure (LBNP), short-radius centrifugation, and entry to microgravity. **RESULTS:** Simulated scenarios were compared to dose-response curves constructed from previously collected experimental data for tilt and LBNP, as well as to historic data for centrifugation and microgravity. Lumped-parameter models can capture the effects of orthostatic stress well across most scenarios but may require further considerations in extreme hypergravity or severe head-down tilt. Further, the introduction of body tissue weight into a lumped-parameter model allows for correct prediction of the changes that occur on entry to microgravity, notably a decrease in central venous pressure compared to the terrestrial 1g supine position. **DISCUSSION:** Modeling expands our understanding of the cardiovascular effects of altered gravity by predicting the pressures, volumes, and flows throughout the body (i.e., in different body compartments) rather than just overall systemic measurements. Model parameters can also be individualized based on a few determined preflight measurements to predict individual responses to altered-gravity or spaceflight countermeasures. Our results contribute to the understanding of cardiovascular responses to unavailable gravity environments (e.g., the Martian environment) and more broadly to the development of countermeasures.

Learning Objectives

1. The audience will understand the use of lumped-parameter modeling to simulate physiological systems in aerospace environments.
2. The audience will learn about the importance of tissue weight in the cardiovascular response to altered-gravity.

Tuesday, 05/07/2024
Grand Suites 2 & 3

4:00 PM

[S-47]: POSTERS: HYPERBARICS AND AEROSPACE MEDICINE

Chair: Allen Parmet

Co-Chair: Aubrey Florum-Smith

[256] VALIDATION OF AN AUTOMATED AI-DRIVEN SMARTPHONE-BASED PUPILLOMETRY DEVICE IN A HYPERBARIC ENVIRONMENT

Doug Campbell¹, Dr. Shawna Pandya², Kyle Foster³, Paul Bakken⁴, Dr. Joe Dituri⁵, Ivo John⁶, Aleksander Bogucki⁶, Radoslaw Chrapkiewicz⁶, Sanjay Manohard⁶

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WITHDRAWN

[257] MYOCARDIAL BRIDGING DIAGNOSIS AND MANAGEMENT IN A STUDENT PILOT CANDIDATE

Zakaria Iloughmane¹, Mohamed Chamsi², Houda Echchachoui², Meryem Zerrik², Mouna El Ghazi², Fahd Bennani Smires², Sidi Mohamed El Khalifa²

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²Aeromedical Expertise Center of the Military Hospital in Rabat, Rabat, Morocco

(Education - Case Study)

INTRODUCTION: This case report describes the discovery of a myocardial bridging in a 24-year-old student pilot candidate. **BACKGROUND:** Myocardial bridging (MB) is a congenital coronary anomaly in which a segment of the epicardial coronary artery traverses through the myocardium for a portion of its length. Typically benign and asymptomatic, myocardial bridging may impair coronary blood flow on exercise, depending on the length and depth of the tunneled artery, and have relevant aeromedical ramifications and exceptionally be responsible for serious life threatening complications. **CASEPRESENTATION:** A 24-year-old student pilot candidate came to the Aeromedical Expertise Center of Rabat (CEMPN) for medical evaluation. He had no previous medical comorbidities and was asymptomatic. The physical examination was unremarkable, the electrocardiogram revealed repolarization disorders in the anterior area, the transthoracic echocardiography shows no abnormality. The exercise stress testing was negative clinically and suspicious electrically (ST depression regressing in recovery). Coronary computed tomographic revealed non-calcified coronary arteries, with long intramyocardial path of the middle and distal left anterior descending (LAD) coronary artery responsible for tight stenosis. Coronary angiography shows non-atheromatous coronary arteries, important milking of the distal LAD, downstream the artery is of very small caliber, the right coronary is dominant and of large caliber and ensure the vascularization of the apex in place of the LAD. **DISCUSSION:** The true prevalence of MB is not accurately known it varies depending on the research method ranging from 2% in coronary angiography and 19% in Coronary computed tomography up to 42% at autopsy. The prevalence among active civil aircrew (pilot and cabin crew) monitored at the CEMPN is 0.4%, all revealed by electrocardiogram abnormalities, the ECG is systematically carried out each medical evaluation. The aviation environment may

expose aircrew to additional physiological stressors (such as hypoxia, hypobaria and potentially sustained acceleration (+Gz)), and present a risk if associated with cardiovascular abnormalities and lead to incapacity to fly. Cardiovascular pathologies constitute the second cause of unfitness in the occupational periodic medical examinations. In our case the decision was an unfitness given the significant modification of the vascularization of the heart.

Learning Objectives

1. Cardiovascular pathologies in aviation medicine can be source of incapacity in flight.
2. The diagnosis of myocardial bridge is not always easy, especially if it is asymptomatic.
3. fitness decision is made on a case-by-case basis.

[258] A REVIEW OF THE EFFECTS OF SPACEFLIGHT ON SPINAL ANATOMY AND FUNCTIONAL IMPLICATIONS FROM A PHYSIATRIST'S PERSPECTIVE

Hannah Uhlig-Reche, Aditya Raghunandan

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(Education - Program/Process Review)

BACKGROUND: Optimal spine health is critical to functional performance. As longer duration space flight (SF) is planned, it is necessary to understand the physiological changes of the spine in prolonged microgravity. This has important implications for function and injury risk during and after long duration spaceflight (LDSF). **OVERVIEW:** LDSF is associated with spinal changes including muscular atrophy, bone remodeling, and disc degeneration. By understanding the physiologic changes that occur during LDSF, physiatrists can optimize astronaut function during and after spaceflight. Establishing effective and feasible countermeasures is imperative. **DISCUSSION:** LDSF is associated with atrophy of spinal muscles including multifidus (MF), paraspinals, and quadratus lumborum. High muscle spindle density in MF plays an important role in proprioception and biomechanics. Disruption of MF directly affects spinal segmental kinematics. There is an increased incidence of herniation within the first year following SF compared to matched controls. In a prospective cohort study of astronauts, reduced MF quality, defined as reduced percentage of lean muscle, following SF was associated with increased incidence of new disc herniation. Risk of lumbar disc herniation after SF is 4.3 times higher in astronauts compared to the general population and risk of cervical herniation is nearly 36 times higher. Although there is a disrupted diurnal cycle of disc compression, disc swelling in microgravity appears to play a lesser role in herniation than muscle atrophy. Discs also undergo molecular changes such as reduction in glycosaminoglycan and changes in extracellular matrix composition. Symptomatic disc herniation may present as axial or radicular pain and may lead to associated neurologic changes or increasing risk of functional decline. Increased bone resorption, particularly of trabecular bone, in prolonged microgravity increases fracture risk associated with acute high physical load demand (i.e., G force changes) or chronic underloading leading to osteoporotic fractures. These spinal changes can significantly affect astronauts' overall function and performance. A combination of exercise, nutrition, and bisphosphonates is effective in countering some of the musculoskeletal changes due to microgravity in LDSF. Additional research is needed to investigate the optimal type, duration, and intensity of exercise required to counteract these physiologic changes of the spine during LDSF.

Learning Objectives

1. Understand an overview of the physiological consequences of long duration space flight on the spine.
2. Be able to describe the risk of intervertebral disc herniations after prolonged exposure to microgravity.
3. Appreciate the functional implications of reduced spinal integrity after long duration space flight.

[259] MILITARY TOXIC EXPOSURES - A HYBRID TWO-WEEK CURRICULUM FOR VETERANS AFFAIRS-BASED INTERNS AND RESIDENTS

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(Education - Program/Process Review)

BACKGROUND: Curriculum about occupational and environmental exposures is not frequently incorporated into medical training. With recent media events covering environmental disasters and spills, and expansion of healthcare and benefits for Veterans exposed to toxic substances following passage of the August 2022 PACT Act, patients will likely have more questions about environmental exposures. Medical providers need to be well-versed in health effects related to toxic exposures to respond to the needs of patients and society at large.

OVERVIEW: A hybrid two-week curriculum was developed to help resident physicians explore the relationship between toxic exposures and health outcomes especially with respect to deployment-related environmental exposures and illnesses. Additional goals include acquiring the skills to take a thorough exposure history, and appreciating the role of environmental health registries for tracking and monitoring the health of groups exposed to specific environmental hazards. This course implements a combination of methods found to be successful in prior OEM courses, especially in achieving learning objectives, improving attitudes towards OEM, and improving self-reported learning efficiency and quality of practice, including use of web-based models with active learning strategies and patient contacts. Active learning strategies include case-based activities (such as generating histories from the perspective of a patient, and developing targeted treatment plans through evidence-based medicine). Patient contacts include conducting Veteran Affairs (VA) environmental health registry exams which includes obtaining occupational/environmental histories, ordering relevant testing, and administering appropriate counseling. Activities are supplemented with additional curricula and examination through the American College of Preventive Medicine, enabling residents to complete the elective with a board-supported certification in military toxic exposures.

DISCUSSION: This course helps providers understand pathways to benefits, how to elicit information about workers exposed to hazardous exposures, and how to monitor workers through surveillance and biomonitoring practices. The knowledge and practical skills developed in this course can be extrapolated to other settings, equipping medical providers with an expanded approach to health and disease prevention and management by including occupation and natural and built environments.

Learning Objectives

1. The audience will learn about a course-development project that teaches resident physicians about toxic exposures and health outcomes, especially with respect to deployment-related environmental exposures and illnesses.
2. The audience will learn about a course-development project that teaches resident physicians to take a thorough exposure history, especially with respect to military exposures.
3. The audience will learn about a course-development project that teaches resident physicians about environmental health registries.

[260] ARTIFICIAL INTELLIGENCE MODELS IN AEROSPACE MEDICINE: A SYSTEMATIC REVIEW

Najmeh Sadeghian¹, Hossein Akbarialiabad²

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WITHDRAWN

[261] PHYSIOLOGICAL AND COGNITIVE RESPONSES TO THE COMBINED EFFECTS OF DEHYDRATION AND HYPEROXIA

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(Original Research)

INTRODUCTION: Military aviators may adopt methods of tactical dehydration and experience heat stress, then subsequently breathe hyperoxic (HO) gas. Research has shown cognitive and physiological decline in response to hypohydration (HH) and HO separately, with both cited as potentially contributing to physiological episodes. Their combined effects have not previously been studied. **METHODS:** N=23 participants (17 male) between 18-45 years old participated in five visits. A within-subjects 2x2 factorial design was used to test four conditions, HO (73% oxygen) or normoxic (NO) and euhydrated (EH) or HH. HH was induced via fluid restriction and sweating from exercise in an environmental chamber (30-32°C, 30% relative humidity). Blood and urine were collected to assess hydration and inflammation (blood only). Cognitive and physiological tests were given, including the Performance Assessment Tool (PAT), hand-eye coordination, grip strength, orthostatic tolerance, pulmonary function, and ventilatory response to exercise. For cognitive testing, repeated-measures ANOVA were used to determine interaction significance, and follow-up t-tests were run. For preliminary serum analysis, a linear mixed-effects model was used to analyze hydration, oxygenation, and their interactions; these variables were considered fixed effects and participants random effects. This protocol was approved by the NAMRUD IRB (NAMRUD.2022.0015). **RESULTS:** PAT total score yield significant interactions between hydration and oxygenation ($F(1,20)=6.049$, $p=.023$, $\eta^2=.232$). This significance is primarily due to increased score for the EH/HO condition compared to the EH/NO condition ($t(20)=3.340$, $p=.003$, $d=.729$). The improved interaction effect is similarly observed in the math ($t(20)=2.821$, $p=.011$, $d=.616$) and manikin ($t(20)=2.678$, $p=.014$, $d=.584$) subtasks. Preliminary analysis of blood markers yielded no significance differences. **DISCUSSION:** This study explored acute combined effects of dehydration and hyperoxia on physiological and cognitive responses. Results showed significant cognitive enhancement, particularly in the EH/HO condition. Specific subtasks, like math and spatial orientation, benefitted from HO. Certain tasks improved even under dehydration when combined with HO, pointing to the nuanced interactions between hydration and oxygenation. These findings have implications for military aviators, suggesting that proper hydration when breathing HO gas may maximize cognitive performance.

Learning Objectives

1. The audience will understand the combined physiological and cognitive impacts of dehydration and hyperoxia, especially within the context of military aviation scenarios.
2. The audience will learn to analyze the specific cognitive tasks, such as mathematical processing and spatial orientation, that are particularly influenced by changes in hydration and oxygenation levels.
3. The audience will be able to recognize the practical implications of the study's findings for professionals, emphasizing the potential for maximizing cognitive performance through appropriate hydration in hyperoxic conditions.

[262] A REVIEW OF DISPARITIES IN THREE POTENTIALLY DISQUALIFYING CONDITIONS IN FEDERAL AVIATION ADMINISTRATION MEDICAL CERTIFICATION

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(Original Research)

INTRODUCTION: Diabetes requiring hypoglycemic medications, epilepsy, and myocardial infarction (MI) are some medical conditions that may disqualify aviators during Federal Aviation Administration (FAA) medical certification. Because chronic conditions can affect different demographic groups unevenly, we reviewed epidemiological literature to identify racial or sexual disparities in these specific conditions. This would allow us to target certain groups for intervention to improve population health outcomes and increase the pool of healthy aviators. **METHODS:** Data were collected from pre-existing literature to elucidate the prevalence or risk ratios of diabetes, epilepsy, and myocardial infarction (MI) in the US according to different demographic factors. We identified more than 30 research papers via online database searches. We employed an age-range criteria of 18-50 years old and searched for figures for Non-Hispanic Black (NHB), Non-Hispanic White (NHW), male, and female populations. **RESULTS:** Our review revealed that the prevalence of diabetes for NHB people is 12.1% whereas the prevalence for NHW people is 7.4% ($p < 0.05$). The prevalence of active epilepsy varied by race and ethnicity, with NHB individuals having a 1.6% prevalence and non-Hispanic adults who identify as multiracial having a 0.6% prevalence ($p < 0.05$). For patients between the ages of 35-84, age-adjusted risk ratio for first acute MI is 1.49 comparing Black men with White men and 1.65 comparing Black women with White women ($p < 0.05$); the risk ratio is yet higher when examining recurrent acute MI. **DISCUSSION:** We have found that in three disqualifying conditions for FAA medical certification, racial disparities exist that impact minority populations in the US. With this knowledge, we can potentially intervene in these populations to increase the pool of healthy aviators. For example, with ample research demonstrating that patient-physician racial and gender concordance significantly impact patient outcomes, increasing physician diversity to better match that of the general population can reduce disparities. Addressing social determinants of health like education and access to healthcare may further improve health inequities. More research is needed to determine the best strategies to improve health for all our potential aviators.

Learning Objectives

1. The audience will learn about racial and sexual disparities in the prevalence of diabetes, epilepsy, and myocardial infarction.
2. The audience will learn how to increase the population of healthy aviators through addressing social determinants of health and increasing patient-physician racial and gender concordance.

[263] ONE DATABASE TO RULE THEM ALL AND IN THE AIRSPACE BIND THEM: NAVAL AVIATION OPERATIONAL INJURY DATABASE (NAVOID) PROGRESS UPDATE

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

(Original Research)

BACKGROUND: Musculoskeletal injuries associated with naval flight environment directly impact flight personnel, readiness, and cost. Aviation-centric acute and chronic injury data relative to operational exposures are critical to providing focused solutions to the fleet and is a knowledge gap. Access to individually-linked operational and medical data would allow identification of exposure/outcome trends across a broad range of reported issues such as back pain/injury, better enabling focused solution development for the fleet. **METHODS:** The external databases identified for initial inclusion are the Navy's Sierra Hotel Aviation Readiness Program (SHARP) and Aeromedical Electronic Resource Office (AERO) flight waiver system. Contact was established and agreements made to access data. The specific medical question investigated was flight waivers and suspensions resulting from low back pain. **RESULTS:** The SHARP data consisted of >20,000 records since 1 JAN 2020 for pilots, naval flight officers (NFO), or aircrew with greater or equal to 100 flight hours. AERO was queried for records with the IDC-10 code M545 low back pain between 1 JAN 2020 – 31 MAY 2023. This search yielded 258 records representing 213 unique individuals. An individual may have between

1 and 3 records (multiple physicals diagnosing, treating, or issuing a waiver for low back pain). An unforeseen problem arose in that AERO uses social security (SS) numbers vice DODID for SHARP. In order to collate the records, the names of the individuals in AERO was used to identify their corresponding record in SHARP and their DODID. However, a severe mismatch became evident in that 133 (>50%) of the records in AERO did not have a corresponding flight record in SHARP. **DISCUSSION:** With less than 50% of the 258 AERO records being linked to SHARP, it is impossible to draw any meaningful relationships between low back pain and operational factors (g-forces, maneuvers). Until the records can be linked with a high degree of accuracy, our question cannot be answered. However, this failure highlights a severe capability gap within Navy and DoD Medicine. While DODID has been mandated since 2015 to reduce PII being compromised, the services continue to use SS for medical records. Updating AERO for DODID is critical to facilitate cross-analysis between databases; focusing research of mitigation strategies and clinical treatment parameters crucial to performance, survivability, and lethality of aircrew.

Learning Objectives

1. The participant will be able to understand the difference between medical conditions and operational factors.
2. The audience will learn about the different reporting systems for medical flight waivers vice operational flight records.
3. The audience will learn that Navy and DOD medical communities continue to use PII as patient identifiers vice more secure and ambiguous methods like DODID.

[264] RNA-TARGETED DRUG REPURPOSING PIPELINE FOR AEROSPACE MEDICINE

Bianca Cerqueira¹, Justin Reese², Diego Galeano³, Afshin Beheshti⁴, Luca Cappelletti⁵, Kim Cates⁶, Harry Caufield², Timothy Smith⁷, Holly Chapapas¹, Meghan Robinson⁸, Paul Sherman⁹
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(Original Research)

INTRODUCTION: New pharmaceuticals take on average 12 years to develop and receive FDA approval. However, there is abundant data in the public domain that can identify existing FDA-approved drugs that can be repurposed. Our goal was to develop graph-based ML and chemical structural-based ML models in a DoD-approved HIPAA compliant cloud environment to identify drugs and small molecules that can address biomedical impacts of high-altitude flight based on mRNA and miRNA signatures obtained from miniature swine high-altitude models. **METHODS:** We leveraged tooling to ingest, extract, and load databases into ARDIS cloud computing environment (AWS GovCloud IL4, HIPAA compliant, Defense Health Agency – verified system). This tooling allows the efficient construction and remixing of knowledge graphs targeted for drug repurposing and application of modern machine learning algorithms to generate a ranked list of relevant small molecules. For this knowledge graph (KG), we semantically integrated data related to drugs, drug targets, microRNAs, protein pathways, and protein-protein interactions, along with several important biomedical ontologies that provide background biological information. We then investigated a graph machine learning model to predict drug – miRNA interactions. We then used the SM2miR database to train a second ML model using miRNA data and extracted chemical structure from PubChem using CIDs. To visualize and provide explainability to the ML results, we developed a visualization component that displays nodes of interest and their relationships in the KG. **RESULTS:** In total, 36 links were predicted between drugs and any of differentially expressed pig genes and human homologs in high-altitude conditions. Broad classes of drugs with predicted links were statins/HMG-CoA reductase

inhibitors, anti-cancer/neoplastic drugs, anti-infective drugs, and analgesic drugs. **DISCUSSION:** We created a knowledge graph environment and applied multiple ML models to identify drugs and small molecules that target differential gene expression associated with high altitude exposure. This platform can be applied to identify candidate marketed drugs for off-label use or repurposing for new indications. The next steps to validate drug predictions would be in vitro/in vivo studies with identified small molecules or retrospective analysis of clinical data sets to confirm therapeutic effects.

Learning Objectives

1. The audience will learn about differential gene expression found in an animal model of high altitude flight.
2. The audience will learn about machine learning algorithms that can be applied to drug repurposing.
3. The audience will learn predicted links between classes of drugs and differential gene expression found in high altitude exposure.

[265] DETECTION OF ABNORMALITIES IN THE HUMAN LUNGS USING MEDICAL IMAGE PROCESSING

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Jamia Millia Islamia, New Delhi, India

WITHDRAWN

[266] A STUDY OF TOBACCO USE BEHAVIOR AND PERCEPTION OF HEALTH RISKS AMONG AVIATION WORKERS IN NORTH INDIA

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WITHDRAWN

[267] VARIABILITY IN AEROSPACE MEDICINE MEDICAL TRAINING GLOBALLY AND ITS IMPLICATIONS

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WITHDRAWN

[268] OPTIMIZING A DRONE NETWORK TO RESPOND TO MEDICAL EMERGENCIES

Daniel Cox¹, Jinny Ye¹, Chixiang Zhang¹, Lee Van Vleet²,
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(Original Research)

INTRODUCTION: Administration of emergency medications in the field is related to medic response time. Delays in response time could potentially be overcome with drones to deliver rescue medications efficiently to the scene for bystander use. Our objective was to evaluate a mathematical optimization simulation for geographical placement of drone bases in reducing response time to scene. To study this, we chose to focus on opioid overdoses because they are frequent in our area and have a potentially life-saving intervention that can be given by bystanders. **METHODS:** Using retrospective data from a local EMS database from January 2016 to February 2019, we created a geospatial drone network model based on current technological specifications and potential base

locations. Genetic optimization was then used to maximize county coverage by drones and the number of overdoses covered per drone base. From this model, we identified base locations that minimize response time and number of drone bases required. **RESULTS:** In a drone network model with 2,327 opioid overdoses, as the number of modeled drone bases increased the calculated response time decreased. In a geospatially optimized drone network with 4 drone bases, response time compared to ambulance arrival was reduced by 4 minutes 38 seconds and covered 64.2% of the county. **CONCLUSION:** Our analysis found that in a mathematical model for geospatial optimization, implementing a few drone bases could reduce response time of 911 calls for opioid overdoses. Therefore, drones can theoretically improve time to delivery of emergency medications in the field. This work can be used to show that use of carefully placed drone stations in areas with difficult terrain or the battlefield could reduce response time to those in need of medical attention.

Learning Objectives

1. The audience will learn about the possible use of drone technology for the delivery of medical care in operational environments.
2. The audience will learn about the use of genetic optimization to assist in the appropriate placement of drone bases to save resources and decreased the response times to medical emergencies. This tool takes a set of inputs and helps determine the best solution for the desired parameters.

[269] RELEVANCE OF CARDIAC, PULMONARY AND CAROTID ARTERY FINDINGS IN A NEW COMBINED CLINICALLY JUSTIFIED VOLUME CT PROTOCOL IN PILOTS AND ASTRONAUTS

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(Education - Tutorial/Review)

INTRODUCTION: With increasing mean age of active pilots and planned extension of maximum age of active pilots early diagnosis and risk stratification of coronary artery disease (CAD) is crucial. The purpose of this study is to evaluate relevance of cardiac, pulmonary and carotid artery findings in clinically justified CT scans of pilots and astronauts with regard to fitness to fly. **TOPIC:** A prospective case review was carried out for 20 consecutive German air force pilots and ESA astronauts at Hospital Porz am Rhein, Cologne, Germany. In cooperation with our institutions we established a clinically justified combined CT protocol consisting of a 3D volume CT coronary angiography (CTCA) including CT-FFR analysis (HeartFlow, Redwood City, CA) to assess coronary artery disease, plaque composition and hemodynamic effects of diagnosed stenoses. In the same protocol a high resolution pulmonary perfusion measurement was performed to exclude structural pulmonary changes and silent chronic pulmonary embolism followed by a spiral CT angiography of both carotid arteries on a 256-slice CT System (GE Revolution Apex). Structured analysis of findings with regard to fitness to fly and incidental findings as well as radiation dose were assessed. **APPLICATION:** Advantages of a clinically justified new combined CT protocol in an aging pilot/astronaut population with increasing prevalence of CAD are presented. Therapeutic or aftercare effects of clinical and incidental findings have to be discussed in interdisciplinary boards. The combined CT protocol of CTCA including CT-FFR analysis, lung perfusion and CTA of carotid arteries allows for detailed risk stratification at very low radiation doses. Randomized prospective multicenter studies are needed to further examine the effects of this new clinically justified screening protocol with regard to fitness to fly

Learning Objectives

1. New clinically justified screening methods in pilots and astronauts with regard to fitness to fly.
2. Examples of incidental findings in screening CTs in aging astronauts and pilots.

[270] SUBJECTIVE AND NEUROHORMONAL COMPARISONS OF A VIRTUAL REALITY VERSION OF THE OPTOKINETIC-NYSTAGMUS DRUM

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(Original Research)

INTRODUCTION: The Optokinetic Nystagmus (OKN) drum has been used to induce nystagmus and symptoms of motion sickness for many decades. The advent of virtual reality (VR) goggles made it possible to virtually create the traditional drum stimulus patterns at less cost and with more stimulus control. The current experiment compared subjective symptoms and neurohormonal responses from the traditional OKN drum experience with those from Vive VR goggles.

METHODS: Healthy college students (n=12) were exposed to the drum and VR-OKN in a crossover design. Half the students received OKN drum exposure first and half received the VR OKN exposure first before the crossover. Comparisons of symptoms and responses were measured before, during, and after exposures using the standard SSQ and salivary assays of cortisol and melatonin. Friedman's test was used to determine if a difference existed between SSQ results and ANOVA was used to evaluate differences in neuroendocrine results, between the two exposures. Additionally, the VR-OKN was presented to the 12 participants in a non-repeated, non-crossover design as either the typical horizontal drum stripes pattern (n=6) or in a vertical stripes pattern (n=6). **RESULTS:** The drum and VR OKN exposures were not statistically different in any segments from any measures. Both drum and VR OKN were significantly different during the exposure segment compared to the pre-exposure and after segments on SSQ. There were no differences between the horizontal or vertical OKN exposures on the SSQ. Exposure to the drum OKN or the VR OKN, significantly reduced the SSQ scores on the crossover results, the VR OKN or the drum OKN, respectively. **DISCUSSION:** The lack of difference between drum and VR OKN measures implies VR-OKN could be used in place of the traditional drum OKN. This is advantageous because traditional methods are unavailable to many clinicians and researchers due to cost and testing inconvenience and far more stimulus presentation options are available with VR. The crossover results suggest that pre-exposure to VR or drum OKN may reduce symptoms on subsequent exposures, perhaps for desensitization to motion sickness. VR-OKN holds promise for reliably and quickly inducing nystagmus in various clinical and research applications.

Learning Objectives

1. The audience will learn about the underlying physiologic principles of optokinetic-nystagmus.
2. The audience will learn about a cheaper, more efficient alternative to testing nystagmus in the setting of diagnosing brain injuries.

[271] BASELINE VESTIBULAR FUNCTION OF AIR FORCE CANDIDATES

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WITHDRAWN

WEDNESDAY, MAY 08, 2024

Wednesday, 05/08/2024

8:30 AM

Grand Ballroom CD South, EF

[S-48]: PANEL: BEHAVIORAL HEALTH AND PERFORMANCE OPERATIONS AND RESEARCH IN HUMAN SPACEFLIGHT

Chair: Stephen VanderArk

PANEL OVERVIEW: BODY: Optimizing behavioral health and performance of astronauts as they prepare for and complete spaceflight missions is a team effort for research and operations. The Behavioral Health and Performance (BHP) Operations Group and BHP Laboratory at NASA Johnson Space Center (JSC), in collaboration with NASA Ames Research Center's Fatigue Countermeasures Laboratory, have a shared goal of promoting optimal performance during all mission phases. This goal is demonstrated by the bi-directional relationship of operations informing research questions, and research results providing guidance to operational work with astronauts. The BHP Operations team within the Space Medicine Division is active in astronaut selection, training, behavioral healthcare services, and work-rest schedule development. The BHP Laboratory is engaged in research in space and analog platforms to address the risks and other challenges associated with future exploration missions beyond low earth orbit. The NASA Ames group works closely with both operations and research at NASA JSC to inform fatigue management services for astronauts and flight controllers and leads circadian desynchrony research. This panel will provide details of recent work by these groups and will demonstrate their shared goals, and contributions toward, optimizing performance, and maintaining the behavioral health and well-being of astronauts during all mission phases. One presentation will discuss the behavioral competency work being completed by NASA and its International Partners to select and train their astronauts using a common model. A second presentation will discuss one example where NASA Operational Psychologists implement this competency work in field trainings with Astronaut Candidates (ASCANs) and assigned crews, with the goal of teaching expeditionary skills, including Teamwork, Communication, Leadership, and Self-care. A third presentation will discuss the relationship between schedule changes and predictions made about crew alertness and performance, which is important data for the BHP Operations and Flight Surgeons to inform their pre-flight and in-flight work with crews. The panel will also include two presentations discussing research by the BHP Laboratory within ISS and spaceflight analogs that use a common set of measures to characterize the behavioral health and performance risks related to exploration missions—providing foundational work for future BHP work to train and monitor astronauts.

[272] COGNITIVE PERFORMANCE IN ISS ASTRONAUTS ON 6-MONTH LOW EARTH ORBIT MISSIONS

Sheena Dev¹, Alaa Khader², Sydney Begerowksi¹, Millennia Young³, Suzanne Bell³, Gilles Clement¹

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(Original Research)

INTRODUCTION: The NASA Human Research Program has identified the risk of decrements to cognitive performance as a primary behavioral health concern. In this study, we systematically assessed