of analyses. 8. Understand modeling and regression at a fundamental level. 9. Understand the Bradford-Hill criteria for causality. **TOPIC:** The Workshop on Aerospace Epidemiology will educate attendees on how the mathematics of epidemiology are applied to aerospace safety and mishap prevention. **APPLICATION:** The mathematics of epidemiology can be broadly and effectively utilized to conduct meta-analyses of aerospace mishap data. The results of these analyses can be used to focus actions and requirements on data driven conclusions that are currently largely absent from the safety process. The mathematical principles to be covered are well accepted but rarely utilized to analyze aerospace mishap data. **RESOURCES:** The course will be accompanied by a customized text serving as a reference for the mathematical applications well established in the public domain. The course will also be accompanied by problems for attendees to work through under supervision so that practical experience in aerospace epidemiology can be obtained. Attendees need to bring an adequately charged laptop computer to the course with a copy of the applicable EPI INFO programming loaded from the Centers for Disease Control & Prevention web site.

Learning Objectives

1. Understand epidemiological terminology & its application to aerospace mishap analysis, be able to employ parametric and non-parametric analyses, determine adequate denominators & evaluate the adequacy of analyses.
2. Be familiar with the import of adequate power, modeling and regression & the Bradford-Hill criteria for causality.
3. Know about EPI INFO™ and have a rudimentary ability to employ it in the field.

Sunday, 05/05/2024 ***9:00 AM***
Randolph 1A, 1B

[S-03]: WORKSHOP: UNDERSTANDING AND MANAGING FATIGUE IN AVIATION

Chair: John Caldwell
Co-Chair: J. Lynn Caldwell

WORKSHOP OVERVIEW: INTRODUCTION: *Human fatigue stemming from lengthy work periods, circadian disruptions, and insufficient sleep poses a serious threat to performance, safety, and general wellbeing. Leaders, healthcare professionals, schedulers, and aircrew members need to understand the causes of fatigue and the scientifically valid strategies for fatigue mitigation.* ***TOPIC:*** *In modern aerospace settings, long work hours, shift work, time-zone transitions, and sleep disturbances are common. These factors often result in personnel reporting for duty in a fatigued state, leading to errors, cognitive difficulties, and mood disturbances that degrade readiness and compromise safety. It is possible to effectively mitigate these difficulties if scientifically validated strategies—administrative, environmental, behavioral, and pharmacological–are systematically applied. This workshop will provide a fully updated, science-based overview of fatigue factors, the effects of fatigue on health and performance, and details on the relevant countermeasures.* ***APPLICATIONS:*** *Effective fatigue management is an important key to optimizing operational performance and safety within aerospace contexts. Up-to-date, evidence-based information on this topic is of broad interest to professionals who are in positions to safeguard and augment human performance in today's demanding operational environments.*

[11] AIR CREW FATIGUE: CAUSES, CONSEQUENCES, AND COUNTERMEASURES

J. Lynn Caldwell, John Caldwell
Coastal Performance Consulting, Yellow Springs, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Human fatigue stemming from lengthy work periods, circadian disruptions, and insufficient sleep poses a serious threat to performance, safety, and general wellbeing. Leaders, healthcare professionals, schedulers, and aircrew members need to understand the causes of fatigue and the scientifically-valid strategies for fatigue mitigation. **TOPIC:** In modern aerospace settings, long work hours, shift work, time-zone transitions, and sleep disturbances are common. These factors often result in personnel reporting for duty in a fatigued state, leading to errors, cognitive difficulties, and mood disturbances that degrade readiness and compromise safety. It is possible to effectively mitigate these difficulties if scientifically validated strategies—administrative, environmental, behavioral, and pharmacological–are systematically applied. This workshop will provide a fully-updated, science-based overview of fatigue factors, the effects of fatigue on health and performance, and details on the relevant countermeasures. **APPLICATIONS:** Effective fatigue management is an important key to optimizing operational performance and safety within aerospace contexts. Up-to-date, evidence-based information on this topic is of broad interest to professionals who are in positions to safeguard and augment human performance in today's demanding operational environments.

Learning Objectives

1. Know how to recognize the dangers of fatigue in various settings.
2. Understand the major causes of fatigue (both operational and physiological).
3. Be able to know and apply one or more scientifically-valid countermeasures for fatigue in specific industrial/operational contexts.

MONDAY, MAY 06, 2024

Monday, 05/06/2024 ***10:30 AM***
Grand Ballroom CD South, EF

[S-04]: PANEL: RECENT DEVELOPMENTS IN NASA AND SPACEX DECOMPRESSION SICKNESS RISK MITIGATION TESTING AND PROTOCOLS

Chair: Andrew Abercromby

PANEL OVERVIEW: *NASA is partnering with SpaceX on development of the Human Landing System, which will require validation of an efficient and effective DCS risk mitigation protocol to enable the high-frequency extravehicular activities (EVAs) planned for Artemis missions. Through a separate agreement, NASA's DCS experts and facilities are supporting SpaceX's historic Polaris Dawn mission, which will include the first commercial EVA. Meanwhile, suited and unsuited human hypobaric ground testing and training occurs on an ongoing basis at NASA's Johnson Space Center (JSC) in support of the International Space Station (ISS), Artemis, and other NASA and commercial programs. This panel will describe results and medical outcomes of two multi-day experimental hypobaric tests aimed at informing Artemis and Polaris Dawn DCS risk mitigation protocols. Recent updates to NASA's rules regarding unplanned breaks in prebreathe protocols are also described, with implications for ISS EVAs, Polaris Dawn, and beyond.*

[12] DEVELOPMENT, VALIDATION AND APPROVAL OF A PLANETARY EXTRAVEHICULAR ACTIVITY PREBREATHE PROTOCOL: NASA EXPLORATION ATMOSPHERE TESTS 1 & 2

Alejandro Garbino[1], Monica Hew[2], Estep Patrick[1], Brett Siders[2], Edgar Lichar[2], Kadambari Suri[2], Constance Ramsburg[3], Karina Marshall-Goebel[4], Andrew Abercromby[4]
[1]*Geocontrol/NASA, Houston, TX, United States;* [2]*KBR/NASA, Houston, TX, United States;* [3]*USN/NASA, Houston, TX, United States;* [4]*NASA/JSC, Houston, TX, United States*

(Original Research)

INTRODUCTION: Denitrogenation prebreathe protocols used to mitigate DCS risk for Space Shuttle and International Space Station EVAs are validated for the microgravity environment, but the significantly increased risk of DCS during equivalent ambulatory surface EVAs make these protocols inapplicable to planetary/Lunar missions as planned by the Artemis program. Living in an "Exploration Atmosphere" of 56.5 kPa (8.2 psia), 34% O_2, 66% N_2 has been recommended by NASA for future Moon and Mars missions as a compromise that balances pre-EVA prebreathe duration, hypoxia, and flammability risk, assuming a 29.6 kPa (4.3 psi) spacesuit. A prebreathe validation campaign at NASA's Johnson Space Center in 2022–2023 has aimed to validate the prebreathe durations and is being operationalized by NASA for use in upcoming Lunar EVAs. **METHODS:** Twelve volunteers lived in a hyboparic chamber for 11 days with an "exploration atmosphere" of 56.6kPa/34% O_2 66% N_2. Subjects acclimated to this atmosphere for 48 hrs and thereafter participated in five 6-hour simulated EVAs at 34kPa/85% O_2/15% N_2 over the course of 11 days. Prior to each simulated EVA, subjects underwent a 20-minute prebreathe at 85% O_2. The EVA simulation was designed to include tasks that are physically and ergonomically representative of future planetary EVAs, proportionate to the subject's VO_2max. Decompression stress was evaluated during the simulated EVA by serial doppler and echocardiographs alternating every 15 min, as well as clinical monitoring for DCS signs/symptoms. Venous gas emboli (VGE) and DCS outcomes were verified against NASA Standard 3001, which guides allowable prebreathe protocol acceptance criteria. **RESULTS AND DISCUSSION:** Venous gas emboli (VGE) were identified during EVAs. No Grade IV VGE were observed. Two cases of mild, Type I DCS were identified in the subjects over the course of 50 EVA exposures. Ten planned EVA exposures were eliminated due to mask fit, metabolic rate, or subject safety concerns. One subject was removed from the study due to presence of left ventricular VGE. Additionally, two doppler techs also experienced DCS, and one case of hypoxia was noted. All cases of DCS resolved with treatment. No cases of severe DCS were observed. The observed incidence (4%, 1.1–13.5% at 95% confidence) met the NASA Standard 3001 criteria leading to the transition of this protocol from research to operational use for upcoming Lunar missions.

Learning Objectives

1. The audience will learn about the NASA Decompression algorithms and their applicability to EVA operations on Artemis/Moon.
2. The audience will learn about decompression diagnosis and treatment methods available for crew and for ground testing operations.

[13] MEDICAL OUTCOMES FROM NASA'S EXPLORATION ATMOSPHERES STUDY

Kristi Ray, Leisa Deutsch, Alex Garbino, Robert Sanders
NASA JSC, Houston, TX, United States

(Original Research)

BACKGROUND: The National Aeronautics and Space Administration's (NASA) Exploration Atmospheres study (EA) was done to evaluate alternative cabin atmospheres, hypoxia risks, denitrogenation protocols, and pre-breathing protocols for future spacecraft designs and planetary surface exploration of the Moon, Mars and beyond. **OVERVIEW:** NASA's EA study evaluated a proposed alternative cabin environment, for future spacecraft habitat, and planetary EVAs. EA included both 3-day and 11-day trials. These trials included a depressurization and saturation to 8.2psia at 34% O_2 with additional depresses to 4.3 psia breathing 85% O_2 for simulated EVAs. There was 1 EVA during the 3-day and 5 during the 11-day trials. The accepted DCS risk is </= 15% risk of type 1 DCS, no type 2 DCS, and </= 20% high grade VGE. There were 5 proposed cases of Type 1 DCS cases that were brought to NASA's DSSMB board for evaluation and a total of 3 cases that were confirmed. The 2 cases that were ruled out had a delayed presentation after the 3-day study and the 3 confirmed DCS cases were from the first 11-day study. Of the 3 confirmed cases, 2 occurred acutely during the study after simulated EVA days and 1 case presented with a >48 hour delay after completion of the study. In addition, there was one case of left sided cardiac bubbling during the 11 day study. **DISCUSSION:** Planning for and executing the medical monitoring and response plan for this project involved many partnerships within NASA and the community. An in-depth treatment algorithm was used during this study including the use of site level oxygen (SLO) (14.7 psia) and hyperbaric treatments using a chamber-side dual-lock deck decompression chamber with multiplace chamber back up available from NASA's NBL and local hospitals. The 2 acute cases were treated with at least 4 hours of SLO with complete resolution and the delayed case was treated by a hyperbaric treatment using USN TT5 with full resolution of symptoms. **CONCLUSION:** Testing of this nature is an essential part NASA's preparation for the upcoming Lunar Artemis missions. The effect of habitation pressure on the natural history of DCS symptoms had not previously been tested for these conditions. Our observations will lead to new protocols in nominal and contingency operations as we prepare for missions back to the Lunar surface while maintaining optimal health and performance of crew.

Learning Objectives

1. The audience will learn about medical outcomes including decompression sickness that occurred in NASA's Exploration Atmosphere study.
2. The audience will learn about medical monitoring and emergency planning for space medicine research.

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

Marissa Rosenberg[1], Andrew Abercromby[2], Amran Asadi[1], Diana Dayal[1], Lichar Dillon[2], Patrick Estep[2], Alejandro Garbino[2], Monica Hew[2], Esther Putman[1], Jaime Mateus[1]
[1]*SpaceX, Hawthorne, CA, United States;* [2]*NASA, Houston, TX, United States*

(Original Research)

INTRODUCTION: SpaceX collaborated with NASA to develop and experimentally characterize the risk of a novel decompression profile to mitigate the risk of decompression sickness (DCS) on the Polaris Dawn mission. **METHODS:** Eight participants, including the Polaris Dawn crew and four age, gender, and BMI-matched participants, experienced the profile in NASA's 20ft Chamber. Conditions were intended to mimic flight, including limiting activity pre-EVA and matching expected metabolic rates during the EVA. The profile comprised: 24h at 11.8 psi, 21% O_2; 19h at 9.5 psi, 26.5% O_2; 6min prebreathe at 9.5 psi, 100% O_2; 90min EVA at 4.5 psi, 100% O_2. Theoretical models estimated the Type I DCS risk as <6% per person. However, these models rely on slow tissue compartments and may not accurately capture the Type II DCS risk. Additionally, there are limited data on profiles with very short 100% O_2 prebreathe times. An experimental characterization of the profile was therefore pursued in order to address these limitations. Ultrasound technicians monitored Venous Gas Emboli (VGE) in the heart at 10-minute intervals throughout the EVA and each observation was scored from 0 to 7, with 7 being the most bubbling. DCS symptoms were queried via medical conference every 30 minutes. **RESULTS:** VGE were detected in 4 participants during the EVA and the highest degree of bubbling was 4, which occurred in one participant. All participants had full bubble resolution upon repress to ambient pressure. No DCS symptoms were reported. **DISCUSSION:** The goal of this test was to characterize the risk of DCS on Polaris Dawn. The results are a promising indicator that this type of decompression profile, which reduces consumable utilization by having a multi-stage decompression followed by a short prebreathe is viable. Generalizable conclusions cannot be made from this study alone, the results are specific to the tested profile. Further testing with a larger subject pool or the effect of variables such as increased EVA duration or suit pressure may be explored.

Learning Objectives
1. The audience will learn how this study helped characterize DCS risk estimates for a novel decompression profile for the Polaris Dawn mission.
2. The audience will learn about a novel gradual decompression profile with reduced time on 100% O_2.

[15] UPDATES TO NASA'S BREAK-IN-PREBREATHE RULES DUE TO TYPE II DECOMPRESSION SICKNESS RISK CONSIDERATIONS

Andrew Abercromby[1], Alejandro Garbino[2], Matthew Makowski[3], Jason Norcross[4], Robert Sanders[1]
[1]*NASA JSC, Houston, TX, United States;* [2]*GeoControl Systems, Houston, TX, United States;* [3]*UTMB, Galveston, TX, United States;* [4]*KBR, Houston, TX, United States*

(Education - Program/Process Review)

INTRODUCTION: Investigation of a central neurological decompression sickness (DCS) case during ground testing at Johnson Space Center identified a break-in-prebreathe (BIP) 13 minutes prior to depressurization as the leading credible cause despite applicable prebreathe payback rules being followed. Applicable NASA rules, for ground and flight, directed 2:1 payback of breaks up to 10 mins in duration, regardless of when a break occurs relative to depress. Full restart of prebreathe is directed following breaks > 10 min. The adequacy of NASA's BIP rules was evaluated prior to resuming hypobaric ground testing or ISS extravehicular activities. **METHODS:** The following information sources were reviewed prior to formulating recommendations: i) Type II DCS case report and investigation findings; ii) documented rationale for existing flight rules, iii) consultations with subject matter experts involved in definition of existing flight rules (several of whom had since left NASA), iv) relevant published literature, v) model estimates of tissue on-gassing and off-gassing, and vi) NASA's operational experience with late breaks in prebreathe. **RESULTS:** NASA's nominal prebreathe protocols are validated via extensive ground testing to ensure DCS risk is reduced to within acceptable limits. Conversely, there exists a paucity of data, no validated models, and limited documentation regarding BIP risk for NASA prebreathe protocols. Flight rules for shuttle and later ISS appear based primarily on expert opinion and an assumption of equal on-gassing and off-gassing rates, which would make 2:1 payback a conservative mitigation for a BIP. Assumption of exponential gas kinetics makes late breaks higher risk, or requiring greater payback, than earlier breaks. Two BIPs have occurred using the current ISS prebreathe protocol, each of which was followed by greater than 2:1 payback and at least 59 minutes of 100% O_2 pre-depress. No DCS cases have been reported during EVA operations. **DISCUSSION:** Interim changes were implemented to protect against late breaks during ground and flight prebreathes by ensuring negligible difference in conservatively modeled ppN2 pre-depress compared to validated protocols. Additional documentation and literature review as well as chamber test planning are ongoing with the objective of further ground and flight rule updates and validation of a BIP risk model.

Learning Objectives
1. The audience will learn about considerations affecting the decompression sickness risk implications of interruptions in prebreathe protocols.
2. The audience will learn that different assumptions regarding nitrogen on-gassing and off-gassing rates during prebreathe interruptions can lead to significant differences in decompression sickness risk mitigation strategies.

[16] AN 'EQUIVALENT STRESS' APPROACH TO MODELING PREBREATHE INTERRUPTION & RECOVERY

Amran Asadi[1], Kaleigh Stabenau[1], Jaime Mateus[1], Alex Garbino[2], Andrew Abercromby[2]
[1]*SpaceX, Hawthorne, CA, United States;* [2]*NASA, Houston, TX, United States*

(Original Research)

INTRODUCTION: Interruptions in prebreathe during extravehicular activity (EVA) preparation may impact decompression sickness (DCS) risk. Interruptions may include technical challenges with environmental control, suit, or oxygen equipment. While a 'restart' may mitigate risk, application to exploration atmospheres and other novel protocol designs is not intuitive, and can come at the cost of lost critical mission objectives. Here, a modeling technique is explored to analytically determine payback requirements, and compared to existing flight data. **METHODS:** A symmetric 1st order model of tissue gas uptake was implemented and used to simulate breaks in prebreathe. Time-dependent functions for environmental and metabolic conditions were developed as inputs based on the In-Suit Light Exercise (ISLE) protocol. Theoretical tissue compartments were chosen with half-time constants (τ) between 5-480 minutes, and tissue tensions simulated from start of mask prebreathe to initiation of airlock depress. Breaks in prebreathe were generated by uniform pseudorandom sampling. Tissue tensions were re-computed and compared between the baseline ($P_{tissue,\tau,b}$) and modified ($P_{tissue,\tau,m}$) runs. The "payback" was computed as the maximum additional oxygen time required for $P_{tissue,\tau,m}$ to reach $P_{tissue,\tau,b}$ across compartments. The process was repeated with 10,000 replicates to map payback requirements. **RESULTS:** Modeled payback time demonstrates dependence upon interruption length and start time. When payback time is length-normalized, start time becomes dominant. A 2:1 payback multiple is suggested to provide near equivalent stress up to 60-80 minutes prior to planned depressurization, concordant with timing of prior events during ISLE in flight. Multipliers increase rapidly to >10x approaching depress. **DISCUSSION:** The addition of simulated interruption to existing biophysical models of tissue gas could provide a tool to accommodate interruption recovery guidance in a variety of future protocol designs, including those used on Polaris Dawn or Artemis 3+. When applied to ISLE, the model suggests a strong dependence of payback multiple on interruption timing. Despite data concordance with known events, dedicated human ground testing is required for model validation.

Learning Objectives
1. Modeling may be a useful tool for providing pre-breathe interruption recovery guidance in real time.
2. Estimated payback multipliers for ISLE are sensitive to interruption start time.

Monday, 05/06/2024 ***10:30 AM***
Grand Ballroom A

[S-05]: PANEL: PILOT SPATIAL DISORIENTATION RESEARCH, MODELING, AND MITIGATION

Chair: Richard Arnold
Co-Chair: Eric Groen

PANEL OVERVIEW: *Pilot spatial disorientation (SD) remains a leading contributory and causal factor in flight mishaps. Emerging knowledge, technology, and research tools are producing better understanding of SD phenomena and their effects on pilot behavior, which should ultimately lead to effective SD countermeasures. This panel will expand upon research featured in our 2023 AsMA panel by highlighting research efforts focusing on understanding, characterizing, and modeling sensory, perceptual, and cognitive factors involved in SD. The panel will discuss research and modeling of vestibular sensation and perception, visual perceptual illusions, sensory integration, and operational contributors to SD. The panelists will also discuss research gaps to inform future SD research, development, and modeling initiatives, in addition to how such efforts may ultimately inform safety mitigations.*

[17] AN ALTERNATIVE TO BAYESIAN INTEGRATION FOR VISUAL-VESTIBULAR AND OTHER MULTISENSORY INTEGRATION

Vincent Billock
Leidos, Inc., at Naval Medical Research Unit - Dayton, Wright-Patterson AFB, OH, United States

(Original Research)

INTRODUCTION: How do visual and vestibular information combine to influence sensory orientation and disorientation? Bayesian reliability weighting is a well-established model that is hard to justify neurally and sometimes has problems with psychophysical data. In 1926 Erwin Schrödinger proposed a nonlinear weighted averaging model for binocular integration that could be an alternative to Bayesian models. Any kind of weighted average, Bayesian or not, will look like suppression when implemented in neurons, because the multisensory system's firing rate will be lower than its best unisensory firing rate. We have applied Bayesian reliability (inverse relative variability) weighting and Schrodinger's nonlinear magnitude weighting to suppressive binocular, audio-visual, audio-tactile and visual-tactile neurons. In every case Schrödinger's weighting was superior on two independent measures. **METHODS:** We examined visual, vestibular and visual-vestibular firing rate data from 89 visual vestibular neurons in macaque MSTd cortex, published by Fetsch *et al*., 2012). We divided the neurons into two groups: convergent neurons (neurons that have the same preferred visual and vestibular headings) and non-convergent neurons. We fit this data to two models: Schrödinger's nonlinear magnitude weighted average and the inverse relative variance model. Both models were completely constrained by the data except for a scaling constant. **RESULTS:** For both kinds of neurons and for the combined dataset Schrödinger's nonlinear magnitude-weighted model outperformed the Bayesian reliability-weighted model. **DISCUSSION:** The results make sense because it would be difficult to implement reliability weighting at the single neuron level. It may also be (given a small number of action potentials in a temporal decision window), that magnitude of response is a better gauge of reliability than inverse variance. The next step is to extend the modeling to psychophysical data on visual-vestibular interactions, including those that result in sensory disorientation.

Learning Objectives

1. Understand that there are at least two possibilities for the optimal combination of visual and vestibular signals in spatial orientation – magnitude weighting and inverse variance weighting.
2. Understand that weighting visual and vestibular signals by magnitude rather than inverse variability works better for visual-vestibular neurons and may apply to perceptual data on visual-vestibular orientation.

[18] TEMPORAL DYNAMICS OF SPATIAL ORIENTATION PERCEPTION AND AWARENESS DURING TRANSITIONS IN THE AVAILABILITY OF VISUAL INFORMATION

Jamie Voros, Lanna Klausing, Aadhit Gopinath, Nicholas Boggess, Sweta Alla, Nicole Rote, Torin Clark
University of Colorado-Boulder, Boulder, CO, United States

(Education - Program/Process Review)

BACKGROUND: Visually degraded environments hold the potential for pilots to misperceive the orientation of their aircraft. When visual information suddenly becomes available (or disappears), such as when flying out of (or into) clouds, the pilot must integrate that information to update their perception of vehicle orientation. Visual information may come in the form of naturalistic cues (e.g., the horizon) or artificial information (e.g., attitude indicator on the aircraft's instrument display). Further, orientation perception (i.e., the "sense" of orientation) may differ from a pilot's orientation "awareness" (i.e., best understanding of vehicle orientation). To our knowledge the temporal dynamics of spatial orientation perception and awareness have not been quantified following transitions in the availability of naturalistic or artificial visual information. **OVERVIEW:** We executed a series of human subject experiments in a motion device capable of roll tilt and lateral translation. Availability of visual cues was dynamically activated or removed on each trial, and presented either naturalistically (horizon and angular vection cues from a dot pattern, presented in virtual reality) or artificially (aircraft attitude indicator shown on a screen). Orientation perception was reported continuously using a subjective haptic horizontal psychophysical task. On separate trials, subjects were instructed to verbally report their orientation "awareness" at discrete moments. In summary, we found it took 3 seconds for subjects to integrate sudden naturalistic visual cues into their orientation perception. In contrast, it took roughly 7 seconds for the attitude indicator information to be integrated into perception. Orientation awareness became consistent with true orientation immediately after the attitude indicator appeared. When visual information disappeared, orientation perception and awareness both gradually transitioned over 7-9 seconds, whether naturalistic of artificial visual information was previously available. **DISCUSSION:** Sudden visual information can rapidly counteract disorientation (particularly instrumentation). Quantifying the temporal dynamics of how visual information affects both orientation perception and awareness is important for understanding pilot spatial disorientation. Further work should be done to examine the difference in impact between orientation awareness vs. perception on the manual operation of aerospace vehicles.

Learning Objectives

1. Understand the influence of visual and vestibular cues on orientation perception.
2. Distinguish between spatial orientation perception and spatial orientation "awareness" contructs.

[19] HYPOXIA ADVERSELY IMPACTS HUMAN VESTIBULAR FUNCTION

Kyle Pettijohn[1], Max Teaford[2], Zachary Mularczyk[1], Anne Crecelius[3], Daniel Merfeld[1]
[1]*Naval Medical Research Unit - Dayton, Wright-Patterson AFB, OH, United States;* [2]*University of Tennessee - Chattanooga, Chattanooga, TN, United States;* [3]*University of Dayton, Dayton, OH, United States*

(Original Research)

INTRODUCTION: Pilots are exposed to a number of factors that may impact their ability to sense where they are relative to the environment, including hypoxia. Despite the potential for hypoxia to affect our ability to sense our spatial orientation, no prior studies have examined its influence on vestibular function in humans. Given this state of knowledge, we performed studies to investigate how hypoxia impacts the vestibular system, specifically vestibular thresholds. **METHODS:** Using a MOOG motion platform in conjunction with a Reduced Oxygen Breathing Device 2 (Environics) we had participants complete multiple sessions of z translation threshold tests while breathing gases with an O_2 content of 20.9%, 15.4%, 14.3%, 12.9%, 11.8%, and 10.7% – chosen to simulate O_2 content found at altitudes of 0 ("baseline"), 8,000, 10,000, 12,500, 15,000, and 17,500 feet. Thresholds were determined based upon participants' responses on a forced choice direction recognition task. **RESULTS:** Fifteen participants completed test sessions at 20.9% and 15.4% O_2. Earth-vertical translation thresholds were 23.5% greater when oxygen content was 15.4% than at baseline ($p=0.005$). A second set of participants was invited to complete test sessions at 20.9%, 14.3%, 12.9%, 11.8%, and 10.7% O_2. Earth-vertical translation thresholds increased as O_2 content decreased. **DISCUSSION:** The results of the present studies suggest that hypoxia resulting from simulated altitudes as low as 8,000 feet, can adversely impact our ability to reliably sense whether we moved upwards or downwards. Specifically, when hypoxic it takes larger movements for us to be able to sense these motions reliably. This is noteworthy because 8,000 feet matches the cabin pressurization required in the US by the FAA for commercial flights. Additional studies are needed to determine if this effect generalizes to other types of motion (e.g., roll-tilts) and if hypobaria

amplifies this effect. Regardless, the results of this study suggest that it may be beneficial to consider supplemental oxygen at altitudes as low as 8,000 feet.

Learning Objectives

1. The participant will learn what vestibular thresholds are and how they relate to aviation.
2. The participant will learn that hypoxia adversely affects humans' vestibular thresholds.

[20] REAL-TIME DETECTION OF PILOT SPATIAL DISORIENTATION TO TRIGGER A PILOT-AIDING SYSTEM

Caroline Dixon[1], Jordan Dixon[2], Taylor Lonner[1], Tristan Endsley[2], Torin Clark[1]

[1]*University of Colorado-Boulder, Boulder, CO, United States;* [2]*The Charles Stark Draper Laboratory, Cambridge, MA, United States*

(Education - Program/Process Review)

BACKGROUND: Pilot spatial disorientation remains a leading cause of Class A mishaps. Sustained vehicle accelerations and rotations that commonly occur during flight may lead to spatial disorientation, particularly in visually degraded environments. Of particular concern, disorientation may remain unrecognized by the pilot until it is too late to make appropriate corrective actions. Many of the sensory (e.g., vestibular) limitations and the brain's central processing mechanisms that contribute to spatial orientation perception are fairly well understood, advancing to the development of computational models. These models input vehicle motions and mimic the pilot's cognitive processing, leading to predicted perceptions of vehicle motion and orientation. These models have previously been used offline, post-flight for accident investigation to assess the potential role of spatial disorientation as a contributor in mishaps. **OVERVIEW:** Here, we aim to develop a computational tool for identifying pilot spatial disorientation in real-time, during vehicle motions. Our approach is to build upon an existing computational model for human spatial orientation perception in order to define a unidimensional metric of spatial disorientation that varies over time based upon vehicle motions. When the spatial disorientation metric is sufficiently high, we envision it to serve as a trigger for real-time interventions helping the pilot recognize their spatial disorientation, regain their spatial orientation, and make appropriate corrective actions. As a first step, we have implemented the real-time computational tool in a ground-based flight simulator and demonstrated feasibility for triggering an adaptive visual display in which the pilot's attention is directed to salient cues of vehicle orientation and motion. This pilot aiding system avoids adding an unnecessary burden when the pilot is not experiencing substantial spatial disorientation. **DISCUSSION:** We aim to show capability of the computational tool to correctly identify when the pilot is experiencing spatial disorientation, and efficacy in reducing performance decrements and enhancing safety. Such a system, if sufficiently capable, could help mitigate the effects of spatial disorientation in real-time, potentially preventing accidents before they occur. We anticipate the computational tool could have benefits across military aviation, commercial and general aviation, and spaceflight.

Learning Objectives

1. Understand the temporal dynamics of pilot spatial disorientation and how computational models can capture those dynamics.
2. Envision how accidents from pilot spatial disorientation could be prevented through a means of triggering a countermeasure in real-time.

[21] SPATIAL DISORIENTATION INTERFERES WITH COGNITIVE PERFORMANCE IN MILITARY HELICOPTER PILOTS

Annemarie Landman[1], Fleur Evertsen[2], Eric Groen[1], Mark Houben[1], Max Mulder[2], René van Paassen[2], Olaf Stroosma[2]

[1]*TNO, Soesterberg, Netherlands;* [2]*Delft University of Technology, Delft, Netherlands*

(Original Research)

INTRODUCTION: Spatial Disorientation (SD) contributes to a substantial proportion of military and civil aviation accidents. So far, research has largely focused on the direct effects of SD on control errors, but little is known about its effect on the availability of cognitive resources. As military piloting tasks are often characterized by high cognitive workload, the potential impact of SD on cognition may strongly affect mission effectiveness as well as safety. **METHODS:** Military helicopter pilots (n = 13) performed 4-minute SD scenarios in a six degrees of freedom Apache AH-64 motion-base simulator, in which the visual environment was presented in Virtual Reality (VR). The scenarios included the following SD stimuli: 1. Leans (vestibular); 2. Sloped cloud deck (visual); 3. Featureless terrain (visual); 4. Brownout (visual); 5. Loss of visual reference during night vision (visual); and 6. Somatogyral illusion (vestibular). Scenario's 1-3 were flown manually, and scenario 4-6 were flown as pilot monitoring. The manual flying task was always to maintain level flight. Corresponding scenarios without SD cues were used as control condition. A cognitive task was performed for 30 seconds during an SD stimulus, and consisted of 10 mental arithmetic calculations presented auditorily every three seconds. **RESULTS:** A repeated-measures ANOVA indicated that SD led to significantly longer response times in the Leans ($p = 0.001$), Featureless terrain ($p = 0.030$) and nearly significantly in the Brownout scenario ($p = 0.066$). Response accuracy was also decreased in the Leans ($p = 0.010$) and nearly significantly in the Featureless terrain scenario ($p = 0.083$). Effect sizes were large ($\eta^2 > 0.40$). Correspondingly, pilots rated the Leans and Brownout scenarios as highly disorienting (score: 4/5 on a 5-point scale), but interestingly, not the Featureless terrain scenario (2/5). **DISCUSSION:** This study shows that SD stimuli can negatively affect cognitive performance of pilots in the pilot flying role and possibly also in the pilot monitoring role. These effects were observed in scenarios which were rated as highly disorienting, but also in a scenario that was not, suggesting that unrecognized SD may also impact availability of cognitive resources. The results imply that effects of SD should be taken into account when managing workload, which is relevant information for the development of crew resource management training.

Learning Objectives

1. The audience will learn about the "Orientation First" principle, and how this applies to pilots.
2. The audience will learn the extent to which spatial disorientation can affect a pilot's capacity to perform cognitive tasks, and what this implies for the underlying processes of spatial disorientation.
3. The audience will learn about which factors could make scenarios for ground-based simulators effective or ineffective for inducing spatial disorientation in a controlled manner.

[22] EFFECTS OF HELMET MOUNTED DISPLAY FORMAT AND SPATIAL AUDIO CUEING ON PILOT PERFORMANCE AND SPATIAL DISORIENTATION PREVENTION

Henry Williams[1], Eric Geiselman[2], Thomas Schnell[3], Darci Gallimore[1], Kendra Carter[1], Dain Horning[1]

[1]*Naval Medical Research Unit–Dayton, Wright-Patterson AFB, OH, United States;* [2]*Air Force Research Lab, 711th HPW, Wright-Patterson AFB, OH, United States;* [3]*University of Iowa, IA City, IA, United States*

(Original Research)

INTRODUCTION: Helmet mounted displays (HMDs) have the potential to improve mission performance by providing visual information regardless of where the pilot is looking. However, with this increased display space it has been shown that pilots tend to look further off-axis and for longer durations, changes in scan behavior that could have unintended consequences. This study was designed to answer three research questions: 1) Do these changes affect the probability of spatial disorientation (SD), as compared to conventional "forward-anchored" displays? 2) What is the best symbology format for HMDs? 3) Can supplementing HMD information with spatial audio cueing improve performance and reduce SD incidence? **METHODS:** In NAMRU-D's Kraken, a Varjo VR-3

headset was integrated into an X-Plane flight simulation to display three different off-axis HMD formats: 1) a simple display format (SDF) with airspeed, altitude, and an aiming reticle; 2) an arc-segmented attitude reference (ASAR), with all SDF elements plus attitude information, and 3) conformal attitude reference (CAR) with the SDF elements plus a conformal horizon line and longitudinal lines converging at zenith and nadir. A traditional head-up-display (HUD) appeared when looking on-axis for all display formats, and all were tested with and without a spatial audio cue performing as a sky pointer. The participant's task was to visually track aerial targets while flying 45° angle-of-bank (AOB) turns while holding 10,000 feet MSL. **RESULTS:** Target-tracking performance was significantly better with ASAR as compared to the other formats, but only for less-experienced pilots, who, when flying with SDF, showed marginally significant trends for lower AOB and altitude error. HMD format had little effect for more-experienced pilots. SDF had the most instrument crosschecks back to "inside" displays, while ASAR had the fewest. Subjective ratings of SD, workload, and preferred format favored both ASAR and CAR. No effect for spatial audio was observed. **DISCUSSION:** The improved target-tracking with ASAR was likely due to fewer crosschecks, allowing pilots to maintain longer visual contact with the target. The trend for lower AOB error with SDF can be explained by more crosschecks with that format. Overall, combined objective and subjective measures tended to favor the ASAR format.

Learning Objectives

1. The audience will understand how Helmet Mounted Displays (HMDs) can change visual scanning behavior.
2. The audience will understand that different piloting tasks (e.g., target tracking vs. turn precision) are likely to be best supported by different HMD symbology formats.

Monday, 05/06/2024 ***10:30 AM***
Grand Ballroom B

[S-06]: SLIDES: CLINICAL PRACTICE GUIDELINES

Chair: Karen Klingenberger
Co-Chair: Marian Sides

[23] USAF EXPERIENCE ON CONGENITAL HYDRONEPHROSIS AND THE APPLICATION OF THE AMRAAM RISK ASSESSMENT MATRIX IN THE DEVELOPMENT OF USAF WAIVER GUIDELINES

Maximilian Lee
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

INTRODUCTION: This presentation will provide United States Air Force School of Aerospace Medicine (USAFSAM) Aeromedical Consultation Service (ACS) experience with congenital hydronephrosis in flying and operational personnel. Additionally, the presentation will provide an overview of the development of aeromedical guidelines for congenital hydronephrosis. Advances in the diagnosis and treatment options for urologic conditions have changed how the USAFSAM ACS assesses aeromedical risk for flyers and operators with congenital urologic anomalies. USAF and ACS waiver management systems were queried using the search terms "obstruction of urinary collecting system" and "hydroureter" that resulted in 54 cases. Twelve cases did not meet the definition of congenital urologic anomalies due to temporary obstruction from acute ureteral stones or cancer. Additionally, three cases were removed because other aeromedical diagnoses were the primary reason for medical disqualification. This resulted in a total of 39 cases of congenital hydronephrosis. With appropriate assessment of renal function, laboratory assessment of chronic renal disease, and absence of other urologic complications, 35 of 39 cases (90%) were granted aeromedical waivers. Demographics, clinical outcomes, advances in minimally invasive procedures, anatomic and functional assessments associated with long-term favorable aeromedical outcomes will be presented. Additionally, we will apply the USAFSAM ACS Medical Risk Assessment and Airworthiness Matrix (AMRAAM) to highlight risk assessment and risk mitigation strategies used in the development of the aeromedical waiver guide. Future research opportunities include longitudinal studies spanning the operational career and comparative studies for long-term renal function and clinical course for surgical versus non-surgical management of chronic ureteral obstruction.

Learning Objectives

1. Identify common conditions found in the development of hydronephrosis and hydroureter.
2. Describe clinical and ancillary findings associated with favorable clinical and waiver outcomes in USAF congenital hydronephrosis cases.

[24] THE 2023 UPDATE OF THE VA/DOD HEADACHE MANAGEMENT CPG – AEROMEDICAL APPLICATIONS

Aven Ford
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: The VA and DoD have recently published an updated clinical practice guideline (CPG) for the management of headache. This presentation will discuss the updated CPG and the available tools and how to apply them to aviators. **TOPIC:** The 2023 update of the Management of Headache CPG includes the full guideline, a provider summary, and a pocket card with updated algorithms. It reviews the expanding list of FDA approved medications and the CPG also evaluated evidence for and provides recommendations regarding nonpharmacologic therapies (complementary and integrative health), neuromodulation devices, injections, procedures, invasive treatments, comparative effectiveness of treatments, and the evaluation and management of medication overuse headache. The Work Group prioritized relevant outcomes frequently cited in the headache literature and, when possible, considered clinically meaningful changes rather than simply statistically significant once. The updated Pocket Card provides an algorithm as well. **APPLICATION:** This CPG presents increasingly strong recommendations for medications that can be considered. The CPG includes an updated a *Strong for* recommendation for multiple CGRP inhibitors for the prevention of migraine. Other potentially aeromedically-acceptable medications recommended for the prevention of migraine include multiple angiotensin receptor blockers, beta blockers, ACE inhibitors, oral magnesium, memantine, and botulinum toxin injections (chronic migraine only). In the acute treatment of migraine, this CPG provides new and updated *Strong for* recommendations for the use of aspirin/acetaminophen/caffeine and for five of the most used triptans. The CPG recommends against gabapentin and Lasmiditan for use in migraine. The CPG recommend physical therapy for the management of tension-type, migraine, or cervicogenic headache and aerobic exercise or progressive strength training for the prevention of tension-type and migraine headache. While there are number of commonly used FDA cleared devices and behavioral interventions for the treatment and/or prevention of headache, none of them had sufficient evidence to achieve anything higher than a *neither for nor against* recommendation.

Learning Objectives

1. The participant will know how to access and use the updated VA/DoD Headache Management Clinical Practice Guideline.
2. The participant will learn about the approach to an aviator with headache.
3. The participant will be able to apply the VA/DoD Headache Management CPG to aviators.

[25] DEHYDRATION-INDUCED COGNITIVE CHANGE IN THE FIGHTER PILOT FOLLOWING LONG-DURATION PASSIVE HEAT STRESS

Nate Deming[1], Stephanie Chayrez[2], Dyana Bullinger[3], Michelle Jilek[4], Joshua Dorcheus[4], John Gassaway[4], Anthony Acevedo[4], Brittaney Nores[5], Carolyn Price Moore[5], Ryan Scott[6]
[1]*U.S. Air Force Academy, Colorado Springs, CO, United States;* [2]*Eglin AFB, FL, United States;* [3]*Human Performance Laboratory, Colorado Springs, CO, United States;* [4]*Luke AFB, AZ, United States;* [5]*Joint Base San Antonio-Randolph, San Antonio, TX, United States;* [6]*Joint Base Langley-Eustis, Hampton, VA, United States*

WITHDRAWN

[26] AN ANALYSIS OF HEAD INJURY RISK FROM EJECTION AND NON-EJECTION SEAT AIRCRAFT ACCIDENTS

Matthew Lewis
RAF Center of Aerospace Medicine, RAF Henlow, United Kingdom

(Original Research)

INTRODUCTION: Some aircrew helmets used by the UK military do not meet the current UK military aircrew helmet impact standard but would typically pass many overseas helmet standards. This study aims to determine if aircraft accident injury outcomes would have differed had the aircrew been equipped with fully compliant helmets rather than the helmets used at the time of the accident. Also, a risk analysis was conducted to establish the overall risk of head injury in ejection and non-ejection accidents. **METHODS:** 317 RAF CAM accident reports were accessed, and the analyses divided into ejection and non-ejection seat accidents. Accidents where head injuries had occurred were interrogated and the cause of fatalities noted. The mechanisms of the head injuries were determined, and these data were used to calculate the overall head injury risks, from windblast slam back, parachute landing or cockpit impacts. **RESULTS:** Non-ejection accidents: 30 aircrew sustained fatal head injuries as well as other fatal injuries in non-survivable high-energy accidents. 2 aircrew sustained survivable multiple injuries coupled with a survivable head injury due to facial trauma. 2 aircrew had isolated survivable head injuries. The risk of a fatal head injury ranged from $1.3x10^{-7}$ to $2.1x10^{-7}$ FH depending on helmet type. Ejection accidents: there were 3 isolated fatal head injuries caused by forces way in excess of that which could be attenuated by any type of helmet. 27 relatively minor injuries occurred primarily because of rotational forces from windblast strikes. There was one survivable parachute landing head injury. The risk of a fatal head injury due to windblast or parachute landing was $1.1x10^{-8}$ and $7.6x10^{-8}$ PFH respectively. **DISCUSSION:** For ejection and non-ejection accidents it was unlikely that the number of fatalities would have reduced had aircrew been wearing helmets with improved impact energy attenuation. In 1 RW accident an isolated non-fatal head injury may have been lessened had the aircrew been provided with better head protection. For the most part aircrew tended to sustain either fatal head injuries coupled with other fatal injuries, or the forces were so extreme that the head protection was of limited benefit. It could be considered that the risk of head injury was as low as reasonably practicable.

Learning Objectives

1. The audience will learn about the causes of head impact injuries sustained during aircraft accidents.
2. The audience will learn about the overall risk of head impact injuries associated with aircraft accidents.

[27] OUTCOME COMPARISON OF LABORATORY-INDUCED AND OPERATIONALLY OCCURRING SPINAL INJURIES IN ROTARY-WING MISHAPS

Danielle Rhodes, Blake Johnson, Katie Logsdon, Frederick Brozoski, Valeta Carol Chancey
U.S. Army Aeromedical Research Laboratory, Fort Novosel, AL, United States

(Original Research)

INTRODUCTION: U.S. Army Aviators can be exposed to large vertical accelerations during a rotary-wing mishap. Black Hawk and Apache pilot seats were designed to meet crashworthiness requirements defined by Military Seat Specification MIL-S-58095A. However, Brozoski et al. (2020) reported that Army aviators are still at risk for thoracolumbar injuries in potentially survivable mishaps. The USAARL is investigating thoracolumbar injury tolerance to vertical loading to improve performance requirements for crashworthy seats. However, it must first be ensured that laboratory exposures are producing injuries like those observed in real-world mishaps. Laboratory-induced spinal injuries will be compared to operationally occurring injuries reported in the U.S. Army Combat Readiness Center (USACRC) aviation mishap database regarding type, severity, and location to ensure the laboratory-induced spinal injuries are operationally relevant. **METHODS:** Fourteen male cadavers were exposed to vertical accelerations (8 mirroring the configuration of MIL-S-58095A and 6 at a lowered pulse) on the USAARL Vertical Acceleration Tower (VAT) and then autopsied. Class A and B survivable rotary-wing mishaps between 1990 and 2018 (n=249), which were recorded in the USACRC mishap database were analyzed. The resulting spinal fracture (fx)/dislocation location, type, and AIS severity were tabulated and compared with the laboratory-produced cadaver injuries. **RESULTS:** Laboratory cadaver testing produced 48 spinal fx/dislocation (with top 3 categories being 17 burst fx, 8 spinous process fx, 9 rupture/dislocation of the intervertebral disc) from both vertical accelerations. The USACRC database yielded 84 spinal fx/dislocation with specified vertebral locations (with the top 3 categories being 53 compression fx, 16 fx type not specified, 7 burst fx). Laboratory-induced and operationally occurring spinal fx were primarily within the thoracolumbar region and ranged from AIS 1 to 3 in severity. **DISCUSSION:** The VAT used in this study is an effective tool for reproducing real-world injury outcomes sustained in rotary wing mishaps, which will be integral to assessing seat performance and injury risk for the Warfighter. Although the categorization of the compressive vertebral body fx differed, similar injury severities and locations were observed between laboratory-induced and reported rotary wing mishap outcomes, enabling the development of operationally relevant injury criteria.

Learning Objectives

1. The most common spinal injury types sustained in Army rotary-wing mishaps.
2. The range of AIS severities sustained in Army rotary-wing mishaps.

[28] EFFECT OF SPACEFLIGHT ON REFRACTIVE ERROR & AXIAL LENGTH: IMPLICATIONS FOR SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME (SANS)

Ganeev Singh[1], Jacob Altholz[2], Geoffrey Bocobo[3], Sara Mason[4], Millennia Young[5], Thomas Oswald[6], Suzi Osborne[6], Bob Gibson[6], Bill Tarver[5], Tyson Brunstetter[5]
[1]*University of Massachusetts Chan Medical School, UMass Memorial Medical Center, Worcester, MA, United States;* [2]*University of Nevada, Las Vegas, Las Vegas, NV, United States;* [3]*Jacobs School of Medicine and Biomedical Sciences, Buffalo, NY, United States;* [4]*Aegis Aerospace, Inc., Houston, TX, United States;* [5]*NASA JSC, Houston, TX, United States;* [6]*KBR, Houston, TX, United States*

(Original Research)

INTRODUCTION: Spaceflight-associated neuro-ocular syndrome (SANS) is a health risk for astronauts manifesting as hyperopic shifts in refractive error, globe flattening, choroidal fold formation, and/or optic disc edema. The pathophysiology behind these phenomena is thought to be due to microgravity-induced intracranial fluid shifts. Examining the specific alterations in ophthalmic measures like refractive error (RE) and axial length (AL), may provide insights into the mechanisms of SANS, especially as some clinical manifestations persist after return to Earth. **METHODS:** Data were obtained retrospectively from medical records of NASA astronauts associated with short-duration Space Shuttle (STS) missions or

long-duration International Space Station (ISS) missions. RE and AL data collected closest to launch and landing for 535 STS and 85 ISS astronauts were included. Each astronaut's RE was converted into angular data (i.e. rectangular vector components converting sphere, cylinder, and axis). Individual values for vision correction were represented as three vectors that represent the spherical component of vision correction (V1) and the magnitude of astigmatism in two predefined directions (V2 and V3). Data were analyzed by linear mixed effects models. **RESULTS:** Significant hyperopic RE shifts occurred in ISS astronauts (+0.15D, p<0.0001) but not in STS astronauts. ISS astronauts experienced significant decreases in AL (-0.122mm, n=55, p=0.0012), while no STS AL pre-flight data were available for comparison. Similar decreases in AL were observed between sexes (Male: -0.122mm, n=39 missions, p=<0.0001; Female: -0.116 mm, n=16 missions, p=0.0299), with equivalent results (p=0.9736). Eye laterality did not significantly affect decreases in AL (Right: -0.100mm, n=55, p=0.0339; Left: -0.137mm, n=55, p=0.0010), (overall p=0.4745). Finally, novice and veteran flyers showed similar changes in AL (Veteran: -0.079mm, n=207, p=0.0006; Novice: -0.175mm, n=185, p=0.0372), with magnitudes not being significantly different (p=0.2597). **DISCUSSION:** Notably, AL consistently decreased across sex, eye laterality, and astronaut flying experience, countering previous work suggesting certain biases. Additionally, significant hyperopic RE shifts occurred in ISS astronauts and were primarily spherical, suggesting that globe flattening may be the primary mechanism of RE changes in SANS. Continued research is critical as NASA and other organizations prepare for future long-duration missions.

Learning Objectives

1. Further characterize the contribution of axial length and refractive shifts related to visual impairment following spaceflight given the various microgravity-induced ocular perturbations that contribute to SANS.
2. Learn how axial length/refractive error changes in SANS do not appear to have a predilection for sex, eye laterality, or astronaut flier experience.

Monday, 05/06/2024 ***10:30 AM***
Grand Hall J

[S-07]: SLIDES: HUMAN PERFORMANCE AND TRAINING

Chair: David Kim

[29] ENHANCING TRAINING REALISM: A COMPARATIVE STUDY OF MASK-ON AND MASK-OFF HYPOBARIC HYPOXIA TRAINING

Yuan Guo Rong Ryan, Seah Zhi Qiang Benjamin, Low Weizheng Jason, See Cheong Yan Brian
Republic of Singapore Air Force, Singapore, Singapore

(Original Research)

INTRODUCTION: The Republic of Singapore Air Force (RSAF) has traditionally used mask-off hypoxia exposure within a hypobaric chamber to train aircrew members to identify in-flight hypoxia. To improve training realism and enhance fighter aircrew members' response to insidious cabin depressurization or OBOGS failure, mask-on hypobaric hypoxia training was introduced in 2019 following the operationalization of a new Breathing Quality Air (BQA)-compatible hypobaric chamber at the RSAF Aeromedical Centre. This study aimed to evaluate the effectiveness of mask-on hypoxia training compared to the traditional mask-off method. **METHODS**: 158 RSAF aircrew members whom had prior experience with mask-off hypobaric hypoxia training were selected to undergo mask-on hypobaric hypoxia training. Data was collected through post-training survey administration of hypoxia symptoms by participants and analysed using descriptive statistics. **RESULTS:** Almost all participants reported the new mask-on training method to be more realistic (98.8%) and effective (97.5%), with most (96.2%) stating a subjective preference for mask-on hypoxia training. The top three symptoms that participants experienced were dizzy/light-headedness, hot and cold flushes, and tingling in fingers/toes. **DISCUSSION:** This study compared mask-on hypobaric hypoxia training with the traditional mask-off hypobaric hypoxia training. Most participants expressed a subjective preference for mask-on training, citing its greater effectiveness and realism. However, it should be noted that the increased realism may not be universally applicable, particularly for aircrew members in non-fighter platforms. A limitation of the study was the inability to determine the direct relationship between reported symptoms and actual hypoxia, as participants' blood oxygen saturations were not measured. Notwithstanding, the top three symptoms reported by participants (i.e., dizziness, hot and cold flushes, and tingling in fingers/toes) were similarly the most common initial symptoms of hypoxia reported in other studies. This suggests that mask-on hypobaric hypoxia training was effective in training aircrew members to recognise their "hypoxia signature" and take appropriate recovery actions.

Learning Objectives

1. The audience will learn about the key components of the new mask-on hypobaric hypoxia training regime conducted in the RSAF Aeromedical Centre.
2. The audience will learn about the results of a subjective survey that compared participants' experiences between mask-off vs mask-on hypobaric hypoxia training.
3. The audience will learn about the top three most common hypoxia symptoms experienced by RSAF aircrew when undergoing mask-on hypobaric hypoxia training.

[30] OPTIMIZING COGNITIVE PERFORMANCE USING AN ACUTE INTERMITTENT HYPOXIA (AIH) PROTCOL

Wendy Olsen[1], Nicholas Napoli[2], Christopher Myers[3]
[1]*National Research Council Research Associate, Air Force Research Laboratory, Wright-Patterson AFB, OH, United States;* [2]*University of Florida, Gainesville, FL, United States;* [3]*Air Force Research Laboratory, Wright-Patterson AFB, OH, United States*

(Original Research)

INTRODUCTION: The optimal goal of any training paradigm is to enhance efficiency, accuracy, and long-lasting retention of relevant knowledge and acquire skill. Our aim is to characterize and determine if an acute intermittent hypoxia (AIH) protocol can facilitate and accelerate the acquisition of novel information that is presented through specific cognitive tasks targeting how humans learn and proceduralize paired associations. The physiological underpinning of AIH induces a positive, long-lasting neuroplastic effect. It is postulated that these benefits may arise from new neuron formation in the hippocampal dentate gyrus, which is essential for learning and memory. We hypothesized participants to demonstrate faster acquisition and longer retention of novel information than their control counterparts. The implications of these findings, optimizing cognitive performance outcomes, can potentially address critical shortages of skilled positions. **METHODS:** Eight healthy participants were recruited for the study. Participants were randomly assigned to a control or AIH group. AIH participants were asked to breathe fifteen trials of a one-minute bout of AIH (10.2% oxygen), immediately followed by a one-minute bout of normoxia (21% oxygen). Each control participant will receive fifteen trials of a one-minute bout of sham-normoxia (21% oxygen), immediately followed by a one-minute bout of normoxia. Subjects experienced the AIH and control protocols 60 minutes prior to performing two cognitive tasks: the digit-symbol substitution task and the change signal task. Physiological data were recorded. **RESULTS:** Preliminary results comparing the AIH and control protocols performance on cognitive tasks examining paired associations indicate significant accuracy differences between the groups at the initial acquisition phase ($F = 13.135$, $p = 0.015$). The follow-up point did not demonstrate significant accuracy differences ($p = 0.061$); however, it is trending towards

significance. Preliminary analyses indicate that the AIH group tends to perform better and faster than the control group. Participant recruitment is ongoing. **DISCUSSION:** The preliminary results indicate the impact of an AIH protocol informing our understanding of optimizing cognitive acquisition utilizing a well-tolerated paradigm that has yet to be explored within healthy adults. The potential application of these findings may inform optimizing training paradigms within the aerospace and aviation environments.

Learning Objectives

1. The audience will learn about a performance enhancing acute intermittent hypoxia (AIH) protocol that has proven tolerance within healthy adults.
2. The participant will be able to understand the potential cognitive neuroplastic benefits of an AIH protocol.

[31] QUANTITATIVE AND QUALITATIVE OUTCOMES OF SELF-ASSESSED SIMULATION-BASED TRAINING OF EXTERNAL FIXATION SKILLS FOR MARS ANALOGUE CREW MEMBERS

Alicyn Grete[1], Julielynn Wong[2], Patrick Bowers[1], William Fraser[3], Jaspreet Randhawa[4], Habila Umaru[5], Jason Barnhill[1], Michael Donohue[6]

[1]*United States Military Academy at West Point, West Point, NY, United States;* [2]*Medical Makers Inc., Toronto, ON, Canada;* [3]*Silatyuk Research, Toronto, ON, Canada;* [4]*Harvard University, Cambridge, MA, United States;* [5]*National Hospital Abuja, Abuja, Nigeria;* [6]*Keller Army Community Hospital, West Point, NY, United States*

(Original Research)

INTRODUCTION: Astronauts on deep space missions are at risk of sustaining fractures. 6 Mars analogue crew members taught themselves to perform uniplanar external fixation of an simulated open tibial shaft fracture using an open-access simulation-based training module that uses locally reproducible, high fidelity 3D printed bone models and a procedure checklist for self-assessment. **METHODS:** While a previously reported analysis of the data showed that confidence with self-performance of this simulation-based procedure improved significantly on all 8 measures evaluated, further analysis was needed to determine the practicality of having crew members undergo this type of training. We report the simulation-based training times and qualitative observations of the simulation-based training experience for the 6 subjects who taught themselves to perform uniplanar external fixation of an simulated open tibial shaft fracture. Each subject tracked and verified the successful completion of each step of the procedure checklist of another subject before performing the simulated procedure themselves. **RESULTS**: It took between 90-120 minutes for subjects to review the knowledge topics (which included watching a skills training video that showed the entire procedure) and between 32-45 minutes for subjects to complete one simulation-based procedure. The first subject opted to practice the procedure twice. All other subjects felt confident to perform the procedure once after assisting a fellow subject perform this procedure by observing and confirming the successful completion of each step of the procedure checklist. Subjects requested clarification of the medical terms in the procedure checklist. **CONCLUSION:** Mars analogue crew members can use open-source, high fidelity, 3D printed bone models and an open-access, self-assessed training module in under 4 hours to become confident and competent in performing a simulated external fixation procedure in an austere environment without access to specialist support from Mission Control. Using a procedure checklist reinforces surgical skills acquisition for crew members. A glossary of terms can be added to the training module to clarify medical terms for primary and back-up crew medical officers who have not completed formal medical training. **LIMITS:** The size of the Mars analogue crew limits the generalizability of our findings. **KEYWORDS:** "long-duration space mission""fracture - external fixation""3D printing"

Learning Objectives

1. The audience will learn about how Mars analogue crew members can use open-source, high fidelity, 3D printed bone models and an open-access, self-assessed training module to become confident and competent in performing a simulated external fixation procedure in an austere environment without access to specialist support from Mission Control.
2. The audience will learn about how using a procedure checklist during simulation-based training reinforces surgical skills acquisition for Mars analogue crew members with no prior medical training.

[32] COMPREHENSIVE ASSESSMENT OF AIRCREW CONDITIONING PROGRAM: ENHANCING PHYSICAL PERFORMANCE AND MITIGATING INJURY IN AIR FORCE FIGHTER PILOTS

Stephanie Chayrez[1], Jared Blake[1], Christopher Parrott[1], Anthony Acevedo[2], Michelle Jilek[2], Clint Copeland[3], Haley Gill[4], Andrew Smietana[5], Brittaney Nores[6], Carolyn Price Moore[6], Ryan Scott[7]

[1]*33rd Fighter Wing, Eglin AFB, FL, United States;* [2]*56th Fighter Wing, Glendale, AZ, United States;* [3]*1st Fighter Wing, Langley AFB, VA, United States;* [4]*4th Fighter Wing, Seymour Johnson AFB, NC, United States;* [5]*49th Wing, Holloman AFB, NM, United States;* [6]*19th Air Force, Randolph AFB, TX, United States;* [7]*Headquarters Air Combat Command, Langley AFB, VA, United States*

(Original Research)

INTRODUCTION: Physical performance is an essential component of operational readiness for Air Force fighter pilots. Adequate strength, endurance, and body composition are crucial to the pilot's ability to perform optimally. The purpose of this study is to assess the impact of an 8-week Aircrew Conditioning Program (ACP) on the Aircrew Conditioning Program Assessment (ACPA), including cervical endurance hold (CEH), inverted row (IR), isometric mid-thigh pull (IMTP), body fat analysis (BF %), and muscle mass (MM). We hypothesized that the ACP would result in significant improvements in the ACPA. **METHODS:** Student pilots (SPs) across two locations (Luke AFB male, $n = 195$, female, $n = 13$; Eglin AFB male, $n = 16$) completed the ACPA before and after an 8-week ACP. A paired-samples t-test was used to determine whether there was a statistically significant mean difference between CEH, IR, IMTP, BF %, and MM ($p<0.05$). This retrospective analysis was approved by the Air Force Research Laboratory Institutional Review Board. **RESULTS:** SPs significantly increased pre-CEH (87. 29 ± 35.67 sec) to post-CEH (117.95 ± 41.25 sec; $t = -14.562$, $p < .001$, $d = 1.00$), pre-IR (21 ± 7) to post-IR (26 ± 8; $t = -15.733$, $p < .001$, $d = 1.12$), pre-IMTP (31.69 ± 5.78 N/kg) to post-IMTP (32.66 ± 5.65 N/kg; $t = -2.746$, $p < .007$, $d = .21$), but not pre-MM (49.80 ± 14.85 kg) to post-MM (49.89 ± 14.61 kg; $t = -.681$, $p = .497$, $d = .05$), or pre-BF % (17.09 ± 5.80) to post-BF % (17 ± 5.45; $t = .746$, $p = .457$, $d = .05$). **DISCUSSION:** The findings suggest that the ACP improved CEH, IR, and IMTP, but not BF % or MM in SPs. The findings provide insight into the readiness of SPs, specifically emphasizing the role of back and neck endurance on the mitigation of injuries associated with operations. The results are expected to inform the development of more targeted and effective ACPs, tailored to optimize the physical performance of Air Force SPs while reducing the risk of injury. Future research should investigate the long-term effects of such training on pilot performance.

Learning Objectives

1. The audience will be able to analyze the training effect on the pre-post Aircrew Conditioning Program measures studied.
2. The audience will be able to discuss the importance that Aircrew Conditioning Programs have on performance and fight-related injury mitigation in fighter pilots.

[33] DEVELOPMENT AND ASSESSMENT OF A VIRTUAL REALITY TRAINER FOR LONG DURATION SPACEFLIGHT

Luca Bonarrigo[1], Esther Putman[1], Wyatt Rees[1], Benjamin Peterson[1], Ellery Galvin[1], Alessandro Verniani[1], Sandra Tredinnick[1], Sage Sherman[1], Karen Mae Baldonado[2], Eric Vance[1], Stephen Robinson[2]
[1]*University of Colorado Boulder, Boulder, CO, United States;* [2]*University of California - Davis, Davis, CA, United States*

(Original Research)

INTRODUCTION: Long duration exploration missions (LDEM) require novel training methods to enable skill maintenance on mission-critical tasks such as entry, descent, and landing (EDL), extravehicular activity (EVA), and habitat maintenance and repair. This research explores virtual reality (VR) as a training modality for astronauts by developing a training environment for mission-critical LDEM tasks through experimental assessment. As a secondary goal, we quantify neurophysiological response in the cerebral cortex during training to assess the potential benefit of training in an adaptive, complex environment as a countermeasure to the neural decrements experienced in spaceflight. **METHODS:** This research has developed an LDEM-specific, multi-environment virtual training simulator called Trinity, which incorporates two Mars-focused environments: EDL and EVA with a surface rover. Each Trinity environment encompasses three subtasks, all presented in a VR headset. **RESULTS:** Using the EDL environment, we compared adaptive training in VR to assess skill transfer going from the virtual training environment to a high-fidelity test environment (physical mock-up). This training condition was compared to a 2D display and a non-adaptive VR training environment (n=24, 12M/12F). We found adaptive VR training to be the most effective regimen, and then evaluated 4 training algorithms for complex tasks (n=32, 16M/16F) to achieve personalized skill acquisition. Our data suggests 2-up, 1-down staircase algorithms as the most effective for skill acquisition. We evaluated the effect of training cadence and VR as a countermeasure to skill degradation (n=41, 24M/17F). Similarly, the EVA environment was evaluated to assess skill transfer. This environment was specifically developed to assess neural activation using functional near-infrared spectroscopy (fNIRS) and electroencephalogram (EEG). **DISCUSSION:** Using mission-critical, Mars-relevant operational tasks, this research investigates high-fidelity, adaptive VR as a promising medium for LDEM training. Specifically, it assesses skills transfer, retention, and generalizability to training in a physical mock-up, and quantifies neural activation to investigate the potential of VR training as a countermeasure for spaceflight neural decrements. Future work includes development of a third environment focused on habitat maintenance and repair. This research is supported by NASA under Grant No. 80NSSC21K1140.

Learning Objectives

1. [The participant will be able to…] Understand the effects of various adaptive algorithms on skill training.
2. [The participant will be able to…] Understand the effects of virtual reality training on cortical brain activation.

[34] THE ROLE OF AI-ASSISTANCE IN POINT-OF-CARE ULTRASOUND SKILL RETENTION FOR SPACEFLIGHT CONTEXTS

Victoria Hurd[1], Michael Del Valle[2], Victoria Kravets[1], Arian Anderson[3], Nhu Nguyen Le[2], John Kendall[2], Allison Anderson[1], Matthew Riscinti[2]
[1]*University of Colorado Boulder, Boulder, CO, United States;* [2]*Denver Health Medical Center, Denver, CO, United States;* [3]*University of Colorado School of Medicine, Aurora, CO, United States*

(Original Research)

INTRODUCTION: Point-of-care ultrasound (POCUS) is a low-cost, low-mass imaging modality that will facilitate healthcare for human spaceflight. However, POCUS skills have been shown to degrade over time, presenting a barrier to effective use during missions. While some astronauts are clinically trained, many only receive limited training on POCUS, making acquisition and diagnostic skills less robust to degradation with time. Artificial intelligence (AI) tool integration may minimize skill degradation for novice, technically competent users, but this has not been experimentally investigated. This is the first study investigating whether AI assistance prevents POCUS skill degradation over time in a subject pool that mimics astronaut candidates. **METHODS:** 30 subjects, (15 male/15 female) were recruited in an IRB-approved human subjects study. Subjects possessed or were working towards a STEM university degree and had no medical training. Subjects were evenly grouped into 2 cohorts: conventional POCUS and POCUS with AI-assistance. During the first data collection session, subjects underwent didactic and hands-on training and performed their first experimental trial. 2 additional trials took place 2 weeks and 8 weeks after the initial session. In each trial, subjects performed 5 renal scans, 5 bladder scans, and 5 bladder volume estimations and completed the System Usability Scale and a self-confidence survey. Images were independently graded by 2 physicians and scored based on target organ acquisition rates. Dependent variables were analyzed via chi-square tests, Levene's tests, and linear mixed effects models. **RESULTS:** The AI-assisted group correctly imaged the bladder more often than the conventional group ($p<0.0005$) and exhibited improved diagnostic accuracy in bladder scans at 2 weeks ($p=0.0416$) but not at 0 or 8 weeks. AI-assistance did not significantly affect skill degradation in renal scans throughout the study. AI-assistance improved perceived system usability over time ($p=0.0407$) but not user confidence. **DISCUSSION:** POCUS AI-assistance improves novice, technically competent user ability to correctly image the bladder and accurately perform bladder diagnostics while increasing perceived system usability with time. These effects augment the applicability of POCUS in spaceflight contexts where astronauts may not have advanced sonography training. Future work includes study replication in more realistic operational scenarios or with upgraded AI algorithms.

Learning Objectives

1. The audience will be able to understand the utility of point-of-care ultrasound in human spaceflight healthcare and recognize that point-of-care ultrasound skills have been shown to degrade over time, necessitating a study that investigates methods of skill degradation prevention for subject pools that mimic that of astronaut candidates.
2. The audience will learn that the integration of artificial intelligence tools into point-of-care ultrasound scanning modalities improved subject ability to correctly capture the bladder and accurately perform bladder diagnostics.

Monday, 05/06/2024 ***10:30 AM***
Grand Hall K

[S-08]: SLIDES: SPACE MEDICINE EVOLUTION

Chair: Allen Parmet
Co-Chair: Karen Keats

[35] This abstract was moved to session S-48.

[36] SPACE-RELEVANT HUMAN-AUTONOMY TEAMING TASK TO STUDY THE MULTI-DIMENSIONAL AND DYNAMIC NATURE OF TRUST

Sarah Leary[1], Jaekeun Sung[1], Victoria Hurd[1], Christian Lee[1], Yimin Qin[2], Zhaodan Kong[2], Torin Clark[1], Allison Anderson[1]
[1]*University of Colorado Boulder, Boulder, CO, United States;* [2]*University of California Davis, Davis, CA, United States*

(Original Research)

INTRODUCTION: Human-autonomy teaming is an integral component of civilian and DoD missions. A human must appropriately trust the autonomous system (AS) to collaborate effectively. Historically, trust has been obtrusively obtained via surveys. Because of this limitation, trust is often modeled as static, rather than dynamic, and one-dimensional, rather than having nuance. For example, Cognitive Trust (CT) forms due to rational, logical thinking, whereas Affective Trust (AT) is based on feelings and emotions. CT and AT are two-dimensions of trust. Our goal is to affect CT and AT in participants and obtain survey-based "ground-truth" trust measurements over time, while simultaneously collecting unobtrusive psychophysiological (e.g., skin conductance responses), neurophysiological (e.g., oxygenated hemoglobin), and embedded measures (e.g., button clicks). We can then use these unobtrusive measures as predictors and develop metrics and models that can infer and predict "ground-truth" trust in real-time. **METHODS:** We developed a space-relevant, human-autonomy teaming task to study multi-dimensional trust. The task was developed using PyQT and displayed on a 2D screen. Participants act as the "supervisor" of their simulated AS teammate in a ground troop monitoring task. The AS receives simulated data captured from ground imaging satellites (e.g., visual and thermal images) and classifies the data as containing troops or not containing troops. The AS then relays the classification and data to the human. The human has the option of agreeing, disagreeing, or ignoring the recommendation of the AS. Throughout the experiment, subjects are compelled to report their trust using a pop-up slider which serves as the "ground-truth". **RESULTS:** To affect CT, we varied AS "reliability". Reliability is the number of correct classifications the AS makes and is 65\% in the "low reliability" cases or 85\% in the "high reliability" cases. To affect AT, we varied AS "explainability". Explainability is how the AS justifies its classification to the human. "Low explainability" is robotic-like rhetoric, whereas "high explainability" is human-like rhetoric. Our results indicate subject trust in the AS varied with reliability and over time. **DISCUSSION:** This task is specifically designed to affect multi-dimensional trust when working with an AS. Future work will build models from psychophysiological, neurophysiological, and embedded measures for real-time trust inference and prediction.

Learning Objectives

1. Biosignals and embedded measures provide an unobtrusive method of inferring trust.
2. Reliability is known to affect Cognitive Trust. This experiment aims to use robotic or human-like rhetoric to affect Affective Trust as well, which is less studied.

[37] USE OF ARTIFICIAL INTELLIGENCE DURING SURGICAL PROCEDURES ONBOARD LONG DURATION EXPLORATION SPACECRAFT

Ryan Lacinski[1], Arthur Formanek[2], Tovy Kamine[3], Ariana Nelson[4]
[1]*West Virginia University School of Medicine, Morgantown, WV, United States;* [2]*Brigham and Women's Hospital, Harvard Medical School, Boston, MA, United States;* [3]*University of Massachusetts Medical School-Baystate, Springfield, MA, United States;* [4]*University of California, Irvine School of Medicine, Irvin, CA, United States*

(Original Research)

INTRODUCTION: While there are no historic instances of surgery onboard spacecraft, given the predicted expansion of space travel, the future need for at least minimal procedural intervention is likely. Numerous factors increase the difficulty and risk of surgery in weightless environments. However, when considering the limited possibility of medical evacuation of critically ill crew members during long duration exploration missions (LDEMs), it is necessary to begin devising onboard surgical intervention support systems. Artificial Intelligence (AI) will soon be implemented to support all aspects of medicine from diagnosis to care. The purpose of this study was to investigate AI tools that could assist a crew medical officer performing surgical procedures onboard spacecraft. **METHODS:** Using PubMed and Google Scholar, we reviewed AI tools applicable to surgical procedures suggested for LDEMs. Keywords included "artificial intelligence" "[procedure]", with [procedure] comprising anesthesia alongside minimally invasive, robotic, endoscopic, thoracoscopic, robot-assisted and open surgery. Article inclusion criteria included publication between the years 2017-2023, as the sentinel paper discussing the transformer architecture essential to ChatGPT among other AI applications was published in June 2017. We excluded any AI tools whose training sets were exclusive to a pediatric patient population. Where applicable, we reviewed only the top 1000 research articles (based on relevance) for each keyword. **RESULTS:** Our literature search yielded a total of 54,577 original research articles and reviews. Nearly 40% (19,970) of all articles were related to the use of AI in anesthesiology. This was followed by publications pertaining to the use of AI in robotic (14.6%, 7956 articles), laparoscopic (14.3%, 7830 articles), endoscopic (10.4%, 5666 articles), minimally invasive (9.6%, 5219 articles) or open (8.4%, 4590 articles) surgery. **DISCUSSION:** Tools for assistive laparoscopic/endoscopic surgical navigation, landmark identification and image analysis were uncovered in this review. Models for ultrasound-guided regional anesthesia and airway management during surgical procedures have also shown preliminary promise. Whether AI could mitigate some of the risk associated with surgical intervention onboard spacecraft requires further investigation, especially considering that any surgical procedure performed on LDEMs is likely to be open, for which there are no current data.

Learning Objectives

1. [The audience will be able to…] appreciate that while surgical intervention onboard spacecraft is associated with immense risk due to numerous physiological and technical factors, intervention may be necessary for critical crew member care during space exploration missions.
2. [The audience will learn about…] the artificial intelligence tools that have been developed to assist medical professionals with space-relevant laparoscopic, endoscopic, robot-assisted and open surgical procedures.

[38] INCREASED GRAVITY AND WEIGHTLESSNESS MAY AFFECT BLOOD PRESSURE THROUGH COMPRESSIVE EFFECTS ON TISSUE

Sara Rothrock[1], Jay Buckey[2], Mimi Lan[3]
[1]*Baylor University, Costa Mesa, CA, United States;* [2]*Geisel School of Medicine at Dartmouth, Lebanon, NH, United States;* [3]*Thayer School of Engineering at Dartmouth, Hanover, NH, United States*

(Original Research)

INTRODUCTION: Blood pressure often decreases in long-duration spaceflight, yet the cause is poorly understood. To investigate if gravitational forces influence blood pressure, data from a G_X centrifugation study were analyzed. G_X centrifugation simulates the high gravity conditions during Earth re-entry. When G_X centrifugation increases tissue weight, it could also elevate resistance to blood flow. If this is true, then reductions in tissue compressive forces by the removal of gravitational forces in weightlessness might reduce total peripheral resistance. **METHODS**: Lindberg et al. examined the impact of G_X centrifugation on cardiovascular parameters. Six healthy subjects underwent G_X centrifugation with cardiac output, heart rate, mean arterial pressure, stroke index, total peripheral resistance, blood pressure, and central venous pressure monitored. Only 4 participants had data going from 1 to 2 G_X. Total peripheral resistance (TPR) under the conditions of 1 and 2G were then re-analyzed and extrapolated to a 0G condition. **RESULTS:** TPR values for the 4 individuals all increased at 2 G_X (#1 705.4 to 1045.9, #2 764.9 to 1083.8, #3, 927.0 to 1154.1, #4, 1273,0 to 1408.1). Extrapolating the centrifugation results to 0 G predicted a TPR of 662. Heart rate was not increased. **DISCUSSION**: Lindberg et al. demonstrated that as the gravitational force increased from 1G to 2G, a substantial rise in TPR occurred. The response to G_X is complex, and the changes in TPR could be from direct effects on vessels or baroreflex responses to reduced cardiac output. In this study, however, the heart rate from 1 to 2G did not increase as expected from a reduction in cardiac output. These changes could be due to increased tissue weight and the

resulting compressive forces. When extrapolating these findings to a 0G environment, the opposite is expected, with reduced resistance to blood flow as tissue weight becomes negligible. This underscores the importance of studying tissue compressive forces and their effects on blood pressure across different gravitational conditions. To further investigate the physiology underlying these changes, future research can leverage numerical modeling techniques. Such modeling enables the simulation and prediction of cardiovascular responses as a function of varying tissue weights in microgravity.

Learning Objectives

1. The audience will understand the impact of weightlessness on blood pressure.
2. The audience will learn about the application of lumped-parameter numerical modeling in predicting the effects of microgravity on the cardiovascular system.

[39] WOMEN'S HEALTH CONDITIONS PERTINENT TO COMMERCIAL SPACEFLIGHT – A SCOPING REVIEW

Satyam Patel[1], Jessica D'Urbano[2], Alexia Tasoula[3], Saswati Das[4], Patrizia Borzi[5], Rachel Steffes[6], Yuka Uemura[7], Wakako Migaki[8], Roshan Patel[9], Yui Okamura[10], Yuika Shimo[11], Begum Mathyk[12]

[1]*Imperial College London, London, UK;* [2]*University of Udine and Trieste, Italy;* [3]*University of Ohio, OH, United States;* [4]*Atal Bihari Vajpayee Institute of Medical Sciences, New Delhi, India;* [5]*Ente Ospedaliero Cantonale - Hildebrand Clinic, Switzerland (CH);* [6]*Kansas City University College of Medicine, Kansas, MO, United States;* [7]*Graduate School of Medicine, Kyoto University, Kyoto, Japan;* [8]*Graduate School of Comprehensive Human Sciences, University of Tsukuba, Ibaraki, Japan;* [9]*Cleveland Clinic Foundation, Cleveland, OH, United States;* [10]*College of Medicine, School of Medicine and Health Sciences, University of Tsukuba, Ibaraki, Japan;* [11]*Nanbu Medical Center & Children's Medical Center, Okinawa, Japan;* [12]*University of South Florida, FL, United States*

(Original Research)

INTRODUCTION: As commercial spaceflight experiences unprecedented growth, it is imperative to note its increasing inclusivity, particularly in terms of female space traveler participation. With space tourism transitioning from a dream to reality for a broader demographic, delving into women's health for the spaceflight paradigm becomes essential. This scoping review consolidates current literature on women's health challenges in commercial space endeavors, pinpointing areas that need clarity. The synthesis will aid primary care providers in executing informed medical risk evaluations. **METHODS:** In alignment with objectives set by the women's health team, a structured search strategy was defined. The focal points of our investigation included areas of reproductive health, hormonal dynamics, and prevalent gynecological conditions such as abnormal uterine bleeding, ovarian torsion, ectopic pregnancy as well other concerns the effect of radiation in space. A search was performed across PubMed, EMBASE, CINAHL, PSYCINFO, and Web of Science for the considered literature extended from 2000 to 2023. Covidence software was used for abstract screening and full text reviews. A rigorous dual-review protocol was employed to assess each article's suitability, with senior members resolving instances of discrepancy. The main goal is to identify studies pertaining to commercial spaceflights. **RESULTS:** Our database search yielded 4,416 potential articles. After screening, a set of articles was chosen for in-depth analysis. The significant portion of the literature pertaining directly to women's health in space conditions was grounded in animal models, while direct data from professional female astronauts was markedly limited or dated. Further, majority of the studies did not stratify and compare participants in terms of sex differences in hormone sensitive tissues. Nonetheless, based on animal models spaceflight may impact reproductive health. **DISCUSSION:** This comprehensive scoping review illuminates the current knowledge regarding women's health in relation to commercial spaceflight, and the limitations on available knowledge due to fewer female participants in spaceflight. It underscores the importance of understanding women's health issues in the unique environment of space, giving direction to primary care providers. Additionally, there's a pressing need to refine commercial spaceflight medical screening procedures and establish evidence-driven safety standards.

Learning Objectives

1. Understand the unique women's health challenges and conditions as they relate to commercial spaceflight, with a focus on reproductive endocrinology, hormonal dynamics, pregnancy, prevalent gynecological conditions, and gynecologic cancer risk.
2. Analyze the current state of literature on women's health in the context of space travel, emphasizing the importance of addressing the gap in knowledge.
3. Recognize the significance of refining commercial spaceflight medical screening procedures to encompass women's health specifics and the establishment of evidence-driven safety standards.

Monday, 05/06/2024 ***10:30 AM***
Grand Hall GH

[S-09]: SLIDES: INDOOR AIR QUALITY

Chair: Roland Vermeiren
Co-Chair: Mark Ivey

[40] INDOOR AIR QUALITY: A NEXUS OF HEALTH AND COGNITIVE PERFORMANCE

Abigail Anderson

Case Western Reserve University and SAFE ASAP Council, Cleveland, OH, United States

(Education - Program/Process Review)

BACKGROUND: For years, efforts to address public health concerns regarding air quality have focused on outdoor air. However, as the average person spends 80-90% of their life indoors, the scientific community and the regulatory system of society should apply this same level of focus to indoor air applications. Recognizing the impacts of indoor air quality on human health, development, and cognition is essential to optimize safety and human performance in enclosed environments. **DESCRIPTION:** The COVID-19 pandemic brought special attention to indoor air and its role in disease transmission. It also highlighted the impact indoor environments have on human health as well as human performance. Indoor air quality can be affected by poor ventilation, tobacco use, dust, pollen, and off-gassing of volatile organic compounds. Natural events such as wildfires and manmade events, such as pollution from vehicles or industry, can also impact indoor air quality. These agents' impacts have been extensively described in outdoor environments, but the prevalence and impact that they hold in an indoor environment should be explored further. **DISCUSSION:** Indoor air quality has been recognized to play a major role in the development of certain health conditions such as asthma, allergies, or other respiratory diseases. However, recent findings have highlighted a connection between contaminated indoor air and changes in concentration levels, decision making abilities, and other markers of human performance and productivity. This presentation will explore the contaminants found in indoor air, review their correlation with health outcomes, and describe the impact of indoor air quality on human performance in terrestrial and aerospace environments.

Learning Objectives

1. Recognize the common factors influencing indoor air quality and identify their effects on human health.
2. Highlight the relationship between poor indoor air quality and cognitive performance, decision making, and concentration.
3. Define the importance for workplace evaluation of indoor air quality to maximize workplace efficiency and safety.

[41] ADVANCED AIR QUALITY SYSTEMS FOR SPACE HABITATS: LESSONS, APPLICATIONS, AND INNOVATIONS

Mollie Scanagatta-Long[1], Anushka Gupta[2], Shavan Patel[3]
[1]*University of Oregon Phil and Penny Knight Campus for Accelerating Scientific Impact and SAFE ASAP Council, Eugene, OR, United States;* [2]*George Washington Milken Institute School of Public Health and SAFE ASAP Council, Washington, DC, United States;* [3]*Northwestern Pritzker School of Law and SAFE ASAP Council, Chicago, IL, United States*

(Education - Program/Process Review)

BACKGROUND: Similar to Earth, spacecraft such as the International Space Station (ISS) encounter challenges with maintaining indoor air quality. To address this, intricate systems must blend air filtration technologies with the management of carbon dioxide (CO_2) levels, temperature, humidity, and oxygen/nitrogen levels, all essential for astronaut health and safety. This air filtration technology has applications beyond the ISS, extending to long-duration missions or potential lunar bases, demonstrating their broader relevance in any enclosed terrestrial environment. **DESCRIPTION:** Air quality systems aboard the ISS face several hurdles. Upkeeping HEPA filters is resource-intensive, requiring crew time and spare part storage. However, these filters do not eliminate all harmful contaminants and microorganisms, jeopardizing long-term health. Carbon dioxide removal systems that use zeolite beds may not effectively reduce CO_2 levels because they require frequent regeneration or replacement. Compounding these issues, energy consumption strains the limited ISS power supply. Adapting these systems for extended missions or varying environments presents difficulties, with microgravity complicating filtration and circulation processes. System failures require manual intervention, highlighting the need for more dependable, self-sustaining systems for the success of longer space missions. **DISCUSSION:** Addressing these challenges calls for new solutions, including compact, energy-efficient filtration, and enhanced pathogen elimination. By adopting sustainable approaches, such as biological systems and progressive chemical methods, we can reduce dependence on resupply missions. Advanced designs, such as fiber-based particulate filters, improve filtration. Moving to autonomous and self-regulating systems eases the demands of resource-intensive maintenance. Human-centric designs are vital, emphasizing crew comfort and streamlined upkeep. Techniques such as UV-C sterilization, advanced filters, and self-sanitizing surfaces will lower maintenance demands. Also, incorporating automation and artificial intelligence (AI) can improve air quality management, decreasing astronaut workload while boosting operational efficiency. Continued research in these air quality systems will aid in ensuring mission success, safeguarding astronaut health, improving terrestrial quality of life, and paving the way for the future of space exploration as commercial spaceflight expands.

Learning Objectives

1. Understand lessons learned from protecting the IAQ in space and applications to terrestrial activities, highlighting similarities and differences between their challenges, solutions, and gravitational environments.
2. Understand accomplishments and challenges of International Space Station air quality management and applications for potential deep-space and lunar base missions.
3. Understand areas for future research into additional methodologies to maintain optimal air quality within closed-loop life support systems.

[42] IN-FLIGHT EMERGENCY RESPONSE AND MANAGEMENT FOR A COMMERCIAL AIRLINE PASSENGER WITH SEIZURES: A CASE STUDY

Azeem Ali
Emirates Airline, Dubai, United Arab Emirates

(Education - Case Study)

INTRODUCTION: This case report describes a 4-year-old passenger who was previously well during boarding, experienced recurrent seizures at cruising altitude, and was unresponsive between each episode. Our unique in-house ground-based medical support (GMS) service based in Dubai managed this case. **BACKGROUND:** Neurological symptoms account for up to 30% of all in-flight medical events that require ground-based medical support (GMS) services. Recurrent seizures and other suspected neurological emergencies are time-sensitive with a limited window for emergency treatment; hence they account for approximately 10-30% of all medical diversions in commercial aviation. Recurrent seizures in a child without recovery between each episode for more than 15 minutes require a detailed review by a GMS service before making an impactful recommendation like an aircraft diversion. **CASE PRESENTATION:** The passenger was a 4-year-old female traveling from Dubai to New York with her parents and previously connected from India, with no problems. Approximately 4 hours after take-off from Dubai at a cruising altitude of 39,000 feet, the aircrew contacted GMS as the child was unresponsive for more than 15 minutes – eyes were repeatedly blinking, and all limbs were limp with spontaneous jerking movements of the legs. Additionally, she had episodes with increased facial and eye twitching. The parents recognized this as a seizure since she was hospitalized and diagnosed one year ago with similar symptoms but was never on anti-seizure maintenance medication. An Emergency Medical Technician volunteer on board assisted with the assessment but was unable to administer parenteral benzodiazepine. The GMS physician made the recommendation to divert the aircraft to the nearest destination in Moscow and the child received emergency medical treatment for status epilepticus. **DISCUSSION:** Enhanced communication and collaboration between cabin crew, medical professionals, and GMS are essential for ensuring optimal in-flight medical care. Although parenteral benzodiazepine is indicated, it is still unclear how the child would have responded with another 11 hours of in-flight monitoring. The aircraft was on the ground in less than an hour, the ambulance began emergency care, and the child was admitted to a local hospital in Moscow. This case highlights the severity of neurological conditions that can lead to a medical diversion and some of the challenges for medical volunteers and GMS physicians.

Learning Objectives

1. Participants will learn how a commercial airline's in-house GMS service remotely manages serious medical conditions inflight and the role of a medical volunteer.
2. The audience will understand the complex decision-making required by an in-house GMS service for recommending a commercial aircraft diversion due to a medical emergency that significantly impacts operations.

[43] NUMERICAL PREDICTIONS OF AIRFLOW PATTERNS ABOARD MILITARY AIRCRAFT TO INFORM CROSS-INFECTION RISK

Karsten Hendrickson, Daniel Reilly, Jennifer Melendez, Christin Duran
Air Force Research Lab, Dayton, OH, United States

(Original Research)

INTRODUCTION: Recent research has shown that infectious particles in exhaled breath and coughs have a median diameter of about 1 micron. Aerosols in this size range do not contain enough mass to deposit efficiently by gravity so transport is dominated by airflow dynamics. Therefore, airflow patterns in aircraft cabins influence cross-infection risk during passenger transport and open-air high-capacity airlift. **METHODS:** We developed high-fidelity computational fluid dynamic models to investigate internal cabin flow physics on a range of military air mobility, special operations, and trainer aircraft, including the C-17, KC-135, C-130J, C-5M, KC-46, KC-10, C-146a, and T-1A. Virtual cabin geometries were generated from real world aircraft cabins using a high-definition laser scanner paired with computer aided engineering. Virtual geometries were uploaded to commercial CFD solver Star-CCM+, on an unstructured polyhedral grid. Boundary conditions for inlet and outlet vents were defined based on either manufacturer provided values or direct measurements for mass flow rates and pressurization during flight. The steady

Reynolds Averaged Navier Stokes equations were solved, with the SST K-Omega turbulence model. Airflow patterns were analyzed for flow direction, speed, and compartment-to-compartment transition. **RESULTS:** Model output indicated that airflow patterns significantly varied airframe to airframe and were dependent on both the locations and configuration of the inlet and outlet vents. Air mass movement direction and efficiency was highly recirculatory in most aircraft, particularly in compartments with relatively large volume to mass flow ratio. **DISCUSSION:** CFD models of airflow patterns provide critical information needed to implement protective actions to mitigate cross-infection on each airframe. In follow-on studies, these models may be manipulated in a high-throughput manner to mimic different cargo and passenger scenarios during different phases of flight. Further, bioaerosols can be introduced to evaluate dispersion, deposition, and removal from the aircraft for different airflow dynamics and bioaerosol release locations.

Learning Objectives

1. Computational simulations can be used to predict airflow patterns and corresponding cross-infection risk in aircraft compartments.
2. Airflow patterns in aircraft are unique by airframe and are highly dependent on the locations and configuration of inlet and outlet vents where the vent configuration may vary based on mission requirements.

[44] FROM RAILS TO ROCKETS: A SYSTEMATIC STRATEGY TO IMPROVING AIR QUALITY IN THE TRANSPORTATION SECTOR

Hyun Yi Woo[1], Anushka Gupta[2]
[1]*University of Szeged Albert Szent-Györgyi Medical School and SAFE ASAP Council, Szeged, Hungary;* [2]*George Washington Milken Institute School of Public Health and SAFE ASAP Council, Washington, DC, United States*

(Education - Tutorial/Review)

INTRODUCTION: Maintaining consistent air quality is not only a fundamental human right and crucial to both environmental and public health, but it also impacts the operation of a developed society. The COVID-19 pandemic exposed the vulnerability of the 16 interrelated "critical infrastructure sectors," designated by the United States Department of Homeland Security, to airborne hazards, whether natural or man-made. Air quality in transportation sectors can be improved by three primary strategies: managing pollution sources, upgrading ventilation systems, and implementing air purification methods. This presentation develops a standardized approach to assess and optimize indoor air quality across various indoor transportation environments—including rail, public transit, cruise lines, aircraft, and aerospace—identifying areas for both improvements and development of uniform standards. **TOPIC:** Traditionally, exposures leading to medical issues have been tackled by clinical specialties, with insights from preventative medical fields. However, in the aerospace environment, beyond mitigating the traditional stressors of flight (hypoxia, temperature, humidity), aerospace and preventive medical specialists are now addressing additional components of indoor air quality (IAQ). Our analysis targets key IAQ parameters, encompassing particulates, volatile organic compounds, other hazardous pollutants, as well as biological contaminants. The review additionally assesses current air quality standards, regulations, practices, and technologies. It delves into their mechanism of action, strength of evidence to support their use, innovations, and potential limitations. **APPLICATION:** This research explores the progression of standards and dives into the current status of IAQ in space and air travel. Moreover it employs this standardized methodology holistically across other modes of the transportation system broadly. Technological advancements in the identified sectors may include elements such as fuel innovations and efficient control systems. Future strategies tailored to the unique needs of each industry will foster broader enhancements in air quality standards. These strategies will not only reduce health risks, but also improve safety and long-term mission outcomes. Nonetheless, it is crucial to recognize challenges while emphasizing the role of aerospace medicine in guaranteeing comprehensive health and safety of transportation systems.

Learning Objectives

1. Understand and compare the ways to address air quality across the rail, transit, cruise, aircraft, and aerospace industries.
2. Learn about cutting-edge technologies being developed and implemented to improve air quality within these sectors.
3. Identify and analyze obstacles impeding air quality advancements, and investigate solutions adopted by these industries for collective problem solving.

[45] FFP2 RESPIRATOR USE MILDLY BUT SIGNIFICANTLY REDUCES AIRBORNE BUT NOT AGROUND O_2 SATURATION IN FLIGHT CREWS

Fabian Hofmann, Thomas Schmitt, Christian Kollmannsberger, Joachim Klaus, Michael Kempf
Lufthansa Group Business Services GmbH, Frankfurt, Germany

(Original Research)

INTRODUCTION: Facemasks proved to be an additional layer of protection in limiting the spread of SARS-CoV-2 onboard commercial airplanes. Therefore, since the start of the COVID-19 pandemic, most countries and airlines implemented mask mandates. However, published data on the effect of mask wear on in-flight O_2-saturation of flight crews is scarce. **METHODS:** We conducted a small case series of volunteers (pilots and cabin crew) to examine the above-mentioned effect. Volunteers were asked to assess their peripheral O_2 saturation (SpO_2) (using a personal pulse oximeter) on ground as well as during different flight phases while wearing a surgical mask (SFM), FFP2 respirator or no mask. We evaluated the average SpO_2 according to mask type, wear time and ambient pressure. We used Mann–Whitney U test to assess statistical significance and Pearson's correlation coefficient to determine correlation. **RESULTS:** Eight volunteers participated in this series. A total of n= 481 measurements was taken during 39 flight legs. SpO_2 aground did not differ between the mask groups (unmasked: μ (mean) = 97.6%, σ (standard deviation) = 1.5%; SFM μ = 97.6%, σ = 0.9%; FFP2 μ = 97.6%, σ = 0.9%). Airborne use of FFP2 respirators resulted in a slight but significant (Δ = 1.1%, $p = 0.00004$) reduction of SpO_2 (unmasked: μ = 95.6%, σ = 1.9%; SFM: μ = 96.2% σ = 1.2% and FFP2: μ = 94.6%, σ = 0.9%). No relevant correlation between the duration of mask use and oxygenation could be demonstrated ($r = -0.16$, $p = 0.12$). Airborne SpO_2 was significantly lower than aground independent of mask type ($p < 0.0001$ for each). **DISCUSSION:** Our exploratory case study suggests, to our knowledge for the first time, that SpO_2 in flight crews is slightly impaired while using FFP2 respirators. This impairment is however minimal (1.1%) and therefore unlikely to have any effect on performance or health. The underlying reasons require further investigation. Limitations to this study exist due to the limited number of participants and measurement data as well as the assumption of statistical independence.

Learning Objectives

1. The audience learns about O_2 saturation in aircrews aground as well as airborne while using different mask types. As a byproduct the audience learns about physiological responses in spO2 to a change in ambient pressure.
2. The audience should be sensitized that there are still questions unanswered that sparked during airline travel throughout the COVID19 pandemic.

Monday, 05/06/2024 ***2:00 PM***
Grand Ballroom CD South, EF

[S-10]: PANEL: HUMAN PERFORMANCE DURING SPACEFLIGHT: EXERCISE, EVA AND INJURY PREVENTION

Chair: Karina Marshall-Goebel
Co-Chair: Judith Hayes

PANEL OVERVIEW: *As we prepare to send humans back to the moon as part of Artemis, the approach to maintaining and optimizing human health and performance to enable mission success on the Lunar surface must be addressed. Exercise countermeasure hardware for exploration missions will have significant mass and volume limitations necessitating new approaches to maintaining fitness inflight. Further, extravehicular activity (EVAs) on the surface of the moon will be more physically demanding compared to microgravity EVAs and will be performed at a cadence that has never been done in human spaceflight history. Optimizing human fitness with exercise countermeasures (pre-flight and in-flight) will be key to preventing injuries and enabling human exploration of the moon in a safe and productive manner. This panel will discuss the relationship between exercise countermeasures, EVA performance, and suited injury with an outlook for surface exploration considerations.*

[46] EVA SPACESUIT INCIDENCE TRACKING

Nathaniel Newby[1], Rachel Thompson[1], Aaron Drake[1], Jeffery Somers[2]
[1]*KBR, Houston, TX, United States;* [2]*NASA, Houston, TX, United States*

(Original Research)

INTRODUCTION: Extravehicular Activity (EVA) suit-related injuries to crew during training and inflight operations are not uncommon. Systematic tracking of these issues has waxed and waned throughout NASA's history. Given two new EVA suits in development and an increase in EVA training, the need for dutiful recording of this data is critical. The Suited User Incident Tracking System (SUITS) was developed in the last decade to track all suited exposures, recording exposure details and any related issues, pains, or injuries that arise. **METHODS:** SUITS data collected from 2017 to 2022 was analyzed for issue frequency and severity for each body location and plotted to visualize where issues were occurring. Clustering techniques using a k-modes approach were also applied to the data set to generate profiles of populations that experienced issues in the suit, and populations that did not. **RESULTS:** A key finding from SUITS is that discomfort and pain observed in the new planetary spacesuits are occurring in new body locations than those experienced in the microgravity space suit (Extravehicular Mobility Unit (EMU)). To date, the lower body and torso regions account for most pain reports in planetary spacesuits whereas most reports in EMU were shoulders and hands. **DISCUSSION:** SUITS will continue to be used to capture exposures for all suit types. As training suit availability improves and training cadence increases in preparation for planetary missions, it is critical to capture and assess all suit incidences. Further, a Suited Anomaly Assessment Team (SAAT) consisting of a broad range of EVA stakeholders was formed to share and act on SUITS data with the goal of developing robust solutions to issues/injuries as they arise. Understanding the types and locations of injuries that occur during suited operations will help inform future work related to EVA fitness training requirements, suit design, and modeling efforts to avoid injury.

Learning Objectives

1. Systematic tracking of suited exposures and issues is critical for understanding the complex interaction between the human and the EVA space suit.
2. As EVA suit issues/injuries arise it is important to share that data with a broad group to ensure robust strategies are developed.

[47] DETERMINING THE IMPORTANCE OF IN-FLIGHT TREADMILL RUNNING CAPABILITIES FOR MAINTAINING ASTRONAUT HEALTH AND PERFORMANCE

Alyssa Varanoske[1], Nicole Strock[1], Brian Prejean[1], Karina Marshall-Goebel[2]
[1]*NASA/KBR, Houston, TX, United States;* [2]*NASA, Houston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: Deconditioning induced via spaceflight is most effectively attenuated through in-flight exercise training. Throughout its evolution, NASA has implemented advances to exercise countermeasures, culminating in the triad of devices currently used on the International Space Station (ISS): a treadmill (T2), cycle ergometer (CEVIS), and resistance exercise device (ARED). Despite high-quality devices and prescriptions, many astronauts experience reductions in aerobic capacity (VO_2peak pre-post mean change: -10%) and strength (knee isokinetic pre-post mean change: -15%). As NASA moves towards exploration missions, imposing size, power, and time constraints on exercise systems in addition to physically demanding surface extravehicular activities (EVAs), providing robust capabilities to protect performance should be prioritized. **OVERVIEW:** Future missions to the Lunar and Martian surfaces will include EVAs requiring ambulation and greater physical exertion than those in Apollo missions. While exercise device concepts planned for exploration missions include resistive and aerobic capabilities, ambulation is not protected. Specifically, the countermeasure planned for Artemis Lunar transit is a flywheel device, which provides both exercise modalities through one resistive cable. While more robust than the flywheel, the devices planned for the Lunar orbital space station and subsequent Mars habitats will provide distinct aerobic and resistance modalities capable of achieving high intensities, but also do not include a treadmill. Recent spaceflight research suggests that greater in-flight running intensity and volume protect against aerobic capacity and strength loss; however, this has not been experimentally confirmed. The Exploration Exercise Treadmill Requirements study is currently underway, aiming to determine the effects of exercising without a treadmill on aerobic capacity, strength, bone density, and sensorimotor function during long-duration spaceflight. **DISCUSSION:** Providing running capabilities on exploration missions may help maintain astronaut fitness and reduce injury. Studies quantifying the effects of using exploration exercise devices are in progress, which will provide critical recommendations on whether a treadmill is a necessary component of the in-flight training regime. This presentation will discuss the capabilities of exploration exercise devices and potential implications of not having running capabilities during spaceflight.

Learning Objectives

1. The audience will learn about the progression of exercise devices used by astronauts in-flight since the initiation of the space program and how these have contributed to mitigating spaceflight-induced physical deconditioning.
2. The audience will learn about the in-flight exercise capabilities currently planned for future exploration missions and how this may impact the extent of physical deconditioning experienced during spaceflight.
3. The audience will learn about the physical demands of extravehicular activities (EVAs) planned for future missions to the Lunar and Martian surfaces and how in-flight exercise capabilities may dictate mission success.

[48] SURFACE EVA PHYSICAL READINESS AND PERFORMANCE OPTIMIZATION: AN INTEGRATED APPROACH

Danielle Anderson
U.S. Air Force, NASA JSC, Houston, TX, United States

(Education - Program/Process Review)

INTRODUCTION: The training environment to prepare for an Extravehicular Activity (EVA) offers a multitude of physical and cognitive challenges posing threats to decreasing physical performance and increasing the risk of sustaining a musculoskeletal injury (MSKI). Due to the historical pattern of MSKIs in preparation for Shuttle and International Space Station (ISS) missions, the Surface EVA Physical Readiness and Performance Optimization (SERPO) team was established to provide a transdisciplinary and operational perspective to integrate the various disciplines required to enhance performance and reduce injury risk while training for lunar surface EVAs. During this section of the panel, the presenter will discuss the need for an integrated approach for maximizing performance and reducing injury risks as it relates to suited training. **BACKGROUND:** Like other operational environments, MSKIs were commonly reported to medical during the increased operational tempo and suited training events for Shuttle and ISS missions. Due to this, an integrated panel of experts, provided several logistic recommendations (e.g avoiding prolonged inverted positions), developed a functional fitness program, termed the "work hardening program", and provided an established pathway for early reporting of injury and quick access to care. These factors, in addition to reduction in training volume, lead to a drastic reduction in the severity of MSKI enhancing the physical readiness of the Astronaut corps. Due to this historical trend, the SERPO team was developed to integrate key stakeholders through multiple divisions at Johnson Space Center to capture a variety of background information related to lunar surface EVAs. This process will allow the team to identify potential tasks and physical and cognitive demands for surface EVAs that may predispose an Astronaut to a performance decrement and further increase the risk of sustaining an injury. **CONCLUSION:** Musculoskeletal injuries are multifactorial and have a complex interworking of risk factors. Based on the understanding of the current literature to date, providing recommendations to enhance physical performance and reduce the risk of injury while preparing for surface EVAs, must include an integrated approach of several disciplines, which will be discussed in the Surface EVA Readiness and Performance Optimization: An Integrated Approach section of this HP panel.

Learning Objectives

1. The Audience will learn about key factors necessary for implementing a successful integrated team for reducing injury risk and enhancing physical performance.
2. The Audience will learn about an integrated approach to identifying MSKI mechanisms, specifically related to surface EVA, and ideas for mitigating training related injuries through early reporting, protective barriers, a training program, and access to conservative and effective care.
3. The Audience will have a framework transferrable to any environment to enhance performance and reduce injury risks.

[49] CONSIDERATIONS FOR HEALTH AND PERFORMANCE DURING SURFACE EXTRAVEHICULAR ACTIVITIES

Patrick Estep[1], Taylor Schlotman[1], Jason Norcross[1], Karina Marshall-Goebel[2], Jeffrey Somers[2]
[1]*NASA - KBR, Houston, TX, United States;* [2]*NASA, Houston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: NASA's objectives for expanding human presence beyond low Earth orbit will require Extravehicular Activities (EVAs) on lunar and planetary surfaces. Given the physiological and functional demands of conducting surface EVAs in a pressurized spacesuit in reduced gravity environments, there is a possibility that crew injury and compromised physiological and/or functional performance may present. **OVERVIEW:** Many human health and performance knowledge gaps exist in regards to exploration EVA that require characterization to ensure safety, reliability, and mission success. To address knowledge gaps, EVA simulations in Earth-based analog environments and/or spacesuit simulators can be utilized to provide valuable insights into task-based physiologic and metabolic costs, cognitive loads, and associated operational limitations to inform future mission concepts. Physical workloads approaching 60% of maximum metabolic rates and 85% age-predicted heart rate maxima; core body temperatures approaching 100° F; and subjective responses indicating limited spare cognitive capacity via Bedford scale have been observed during ground-based exploration EVA simulations in the NASA Active Response Gravity Offload Simulator (ARGOS) and Neutral Buoyancy Lab (NBL) during simulated planetary EVAs in pressurized suits. Further, ground-based EVA analogs vary in their ability to simulate planetary EVA and resulting physical workloads. **DISCUSSION:** Metabolic costs, thermal burdens, functional strength, and cognitive impacts have been and must continue to be assessed in ground-based analogs to fully characterize operational demands and crew readiness levels for exploration EVA. Considerations should be given to enabling a new concept of high-tempo surface EVA operations and associated work-rest intervals, understanding human health and performance impacts of evolving commercial suit designs and capabilities, and predictive modeling and decision support capabilities to enable safe and successful EVA operations.

Learning Objectives

1. Understand the high-performance physiological and functional demands, associated risks, and open knowledge gaps of operating in a self-contained extravehicular activity or training spacesuit in various gravity fields and system environments.
2. Understand ongoing and forward efforts to close knowledge gaps associated with exploration extravehicular activities.

[50] EVALUATION OF AEROBIC CAPACITY IN RELATION TO SIMULATED LUNAR SURFACE EXTRAVEHICULAR ACTIVITIES

Nicole Strock[1], Dillon Frisco[2], Patrick Estep[3], Jason Norcross[1], Taylor Schlotman[1], Brian Prejean[1], Karina Marshall-Goebel[4]
[1]*KBR, Houston, TX, United States;* [2]*JES Tech, Houston, TX, United States;* [3]*GeoControl Systems, Houston, TX, United States;* [4]*NASA, Houston, TX, United States*

(Original Research)

INTRODUCTION: Astronauts will need to be physically prepared to successfully execute strenuous Extravehicular Activities (EVA) on the Lunar surface. Compared to Apollo missions, Artemis missions will include EVAs of increased physical demand, frequency, and duration, thus requiring adequate fitness to successfully and safely complete mission objectives and potential contingency scenarios. Currently, aerobic fitness standards for partial gravity (g) surface EVAs are not well supported by high-fidelity EVA analog data. This investigation aims to characterize metabolic demands from Lunar analog EVA simulations in relation to the current NASA standards for celestial partial-g aerobic fitness (aerobic capacity (VO2pk) ≥36.5ml/kg/min). **METHODS:** To evaluate current Lunar EVA aerobic fitness requirements, a pilot study was performed to characterize metabolic rates during 6 hour simulated EVAs. The EVAs were performed in pressurized MKIII (n=2 male) and xEMU (n=3 female) spacesuits offloaded to 1/6 g in the NASA Active Response Gravity Offload System. VO2pk was assessed via graded exercise testing on a cycle ergometer and physical workload was quantified as percent of VO2pk. **RESULTS:** Four out of five subjects did not meet the current NASA celestial surface EVA aerobic standard (3 xEMU, 1 MKIII; 35.1±0.9 ml/kg/min). During simulated EVAs, subjects (xEMU: 35±1 ml/kg/min; MKIII: 44±10 ml/kg/min) worked at an average 36% VO2pk (xEMU) and 31% VO2pk (MKIII). For xEMU subjects, the tasks with the greatest average metabolic rates were 2km treadmill traverse (0% grade: 47.2% VO2pk [max 69.1%]), object relocation (45.2% VO2pk [max 60.5%]), and 1.5km traverse (0% grade: 45% VO2pk [max 59.7%]). For MKIII subjects, the tasks with the greatest average metabolic rates were 0.5km treadmill traverse (30% grade: 35.4% VO2pk [max 45.5%]), object relocation (31% VO2pk [max 40.8%]), and treadmill traverse (0% grade: 29.9% VO2pk [max 45.9%]). **CONCLUSIONS:** While average metabolic rates

for simulated Lunar EVA fall within sustainable work ranges of 30–40% VO2pk and life support system limitations, task-specific metabolic rates exceed this range and may indicate that greater fitness is necessary for more strenuous tasks expected to be performed on the Lunar surface. As few subjects met the standard, more data is needed to adequately evaluate the NASA 3001 standard.

Learning Objectives

1. The audience will learn about the celestial surface EVA NASA 3001 aerobic capacity standard.
2. The audience will learn about high metabolic demand tasks completed in simulated extravehicular activities.

Monday, 05/06/2024 ***2:00 PM***
Grand Ballroom A

[S-11]: PANEL: SUBTLE SPATIAL DISORIENTATION IN COMMERCIAL AIRCRAFT

Chair: Eric Groen

PANEL OVERVIEW: *The somatogravic illusion is a false sensation of pitch which is commonly associated with accelerated flight in (military) high-performance aircraft. However, accident investigations suggest that the illusion also occurs in less agile commercial aircraft, where it may manifest itself in a more subtle way than in fast-moving jets. This panel will give a comprehensive analysis of the appearance of the somatogravic illusion in commercial aircraft. The first presentation will provide an overview of accidents and incidents with transport airplanes related to spatial disorientation (SD), with a focus on the somatogravic illusion. The second presentation will shed light on how the somatogravic illusion develops during a go-around, based on the analysis of two mishaps with a mathematical model of human spatial orientation perception. The third presentation will describe the results of an in-flight study on the inversion illusion, which is a form of the somatogravic illusion that occurs when an aircraft levels off after a climb, similar to a go-around. The fourth presentation will provide an analysis of a helicopter mishap where the somatogravic illusion seems to have played a role. The final presentation will describe a closed-loop model which may provide insight in how the somatogravic illusion may affect pilot control inputs.*

[51] A REVIEW OF SD ACCIDENTS AND INCIDENTS IN TRANSPORT AIRPLANES

Randy Mumaw
University of Pittsburgh, Pittsburgh, PA, United States

(Education - Program/Process Review)

BACKGROUND: Vestibular illusions (spatial disorientation, or SD) can occur in flight when the pilot misperceives airplane movements or accelerations. These illusions can lead to inappropriate control actions (or failures to act), and subsequently a safety event (airplane upset or accident). While there is a well-established record of vestibular illusions leading to safety events in military jets (e.g., Stott, 2013), there was a common belief that these illusions do not afflict pilots of slower and less-maneuverable large commercial transports. However, we believe there is strong evidence that these vestibular illusions occur in transport airplanes, as well, and that these events and their causes need to be better understood. **OVERVIEW:** A review of transport airplane accidents and incidents identified, on average, about one SD-related safety event per year for the last 20 years (Mumaw et al., 2015). These safety events were responsible for 1126 fatalities. This review of 20 transport airplane safety events suggests that 11 of the 20 events were likely the result of a somatogravic illusion. Nine of those 11 somatogravic events resulted in an airplane crash and fatalities; these events produced 512 fatalities. Seven of these 11 somatogravic events were preceded by a go-around maneuver. This paper will describe those events to understand the factors that may contribute to the onset of the somatogravic illusion. **DISCUSSION:** Reduced go-around thrust was considered as a potential mitigation for reducing somatogravic-related events. Other factors that might make this illusion more likely, according to existing vestibular models, are vertical acceleration, longitudinal acceleration, and perhaps pitch rate and maximum pitch angle. In this presentation, I will review the "somatogravic" accidents and incidents to determine whether these flight parameters were outside the expected range of a large set of "normal" go-arounds (go-arounds with no safety event). Further, I will discuss other forms of vestibular illusions in commercial transports. Analysis of the events that did not appear to be the result of a somatogravic illusion suggested two other vestibular illusions that might play a role in transport airplane accidents: the somatogyral illusion and the sub-threshold roll illusion. I will also provide examples of these events.

Learning Objectives

1. The audience will learn about the influence of vestibular illusions on safety events in large commercial transport airplanes.
2. The audience will learn how well these vestibular illusions are linked to the characteristics of the go-around maneuver.

[52] MODEL ANALYSIS OF SOMATOGRAVIC ILLUSION IN ACCIDENTS RELATED TO A GO-AROUND

Torin Clark[1], Michael Newman[2], Randall Mumaw[3], Mark Houben[4], Eric Groen[4]
[1]*University of Colorado-Boulder, Boulder, CO, United States;* [2]*Reorient Corporation, Philadelphia, PA, United States;* [3]*San Jose State University, San Jose, CA, United States;* [4]*TNO, Soesterberg, Netherlands*

(Education - Program/Process Review)

BACKGROUND: Sustained aircraft forward acceleration can often lead pilots to have an illusory sense that the aircraft is pitching. Known as the somatogravic illusion, this can occur during a "go-around" maneuver when a landing approach is aborted. The resulting pilot spatial disorientation can coincide with incorrect pilot control inputs which can lead to an accident due to go-arounds often occurring at low altitudes. Conceptually, it is thought the somatogravic illusion occurs due to the otoliths of the vestibular system (and other graviceptors) being unable to distinguish between inertial acceleration and gravity. However, this is difficult to quantitatively capture during piloted aircraft flight. Computational models of human spatial orientation perception offer a means of studying the somatogravic illusion. **OVERVIEW:** Here, we applied a computational "observer" model to two inflight go-around scenarios in which the somatogravic illusion was thought to have potentially occurred. Specifically, the flight data recordings of the aircraft motion trajectories were processed to serve as inputs to the computational model. The model mimics the mechanisms which the brain is thought to use to perceive self-orientation. By inputting the aircraft motions which the pilots were exposed to, the models can provide a prediction of the pilots' perceptions of aircraft orientation and motion during the go-around maneuvers. Comparing the model predictions of pilot perception to actual aircraft orientation can help to quantitatively identify the occurrence of the somatogravic illusion. **DISCUSSION:** We aim to show the potential for applying a computational model to go-around flight maneuvers to better understand the somatogravic illusion. Comparing two flight scenarios will help identify commonalities which may occur leading to spatial disorientation during go-arounds. Studying previous flight scenarios, such as these, will help to elucidate potential means for preventing future spatial disorientation accidents.

Learning Objectives

1. Describe the mathematical mechanisms involved in modeling human spatial orientation perception.
2. Understand the quantification of the somatogravic illusion in real flight data using computational modeling approaches.

[53] RE-EXAMINATION AND RE-CALCULATION OF THE INVERSION ILLUSION

Geoffrey McCarthy
None, Portland, OR, United States

(Education - Tutorial/Review)

INTRODUCTION: Reports on the perception of the theoretical rotation of the G vector while pushing over (bunting) are conflicting. We have identified several large aircraft incidents which might have produced an illusion of inversion. This extreme form of the somatogravic illusion is impossible to reproduce in a centrifuge simulator and has been examined rarely in flight. In 1990, Money et al. subjected five passengers in a T-33 to a transition from +1 to -1G in 3 seconds to search for perception of this Inversion Illusion. Two perceived a backwards rotation of the G vector and inversion. We performed another experiment in flight to further investigate this illusion. **METHODS:** Each of ten subjects was flown in the Royal Air Force Institute of Aviation Medicine 2-seat jet Hawk or Hunter through this manoeuvre: With sun visor down and eyes closed, the subject was asked to report what the aircraft was doing. Flight profile: stabilise 30 seconds, accelerate level from 200 to 250 Kts (+ 0.15 - 0.25 Gx), gently pull to 250 Kts, 3000 ft/min climb. After 30 sec, push over to -1G in 3 seconds and hold 3 seconds. **RESULTS:** Eight of 15 manoeuvres produced sensations of inversion in seven of ten subjects. Two subjects reported backwards rotation of the aircraft to the inverted; one other felt a rotation of indetermined direction, four felt sudden inversion. 2/2 naive non-pilots, 5/6 pilots, and 0/2 test pilots experienced this illusion. Computation of the perceived vector will be demonstrated. Further, we will show the perceived vector, and probable pilot control inputs from contemporary orientation models. Also the possibility of reproducing the necessary conditions in a contemporary 6 degree of freedom centrifuge, e.g. Desdemona, Kraken will be discussed. **CONCLUSIONS:** The Inversion Illusion exists; not all subjects perceived it . Paradoxically, the rate of pitch may be greater at slower speeds, and large aircraft manoeuvres may induce this illusion.

Learning Objectives

1. Attendees will learn how to explore Spatial Disorientation in flight, with specific focus on an extreme form of the Somato-Gravic Illusion, the Inversion Illusion.
2. Attendees will learn that large aircraft maneuvers can impose accelerations that may induce the Somato-Gravic illusion, not just highly maneuverable small aircraft.

[54] A VECTOR ANALYSIS OF ACCELERATION EVENTS RESULTING IN SOMATOGRAVIC ILLUSIONS

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

(Education - Program/Process Review)

INTRODUCTION: The typical somatogravic (SMG) illusion associated with take-off or go-around maneuvers is accompanied by a resultant gravito-inertial force (GIF) vector that is both increasing in magnitude as well as rotating in direction from head-to-seat orientation to behind the pilot. The associated pilot perception is an increasing pitch-up, which if the pilot responds with forward stick/cyclic input, results in the positive feedback somatogravic illusion of ever-increasing pitch-up. The Atlas Air Boeing 767 mishap discussed in detail in the previous presentation was associated with a pilot unloading maneuver prior to the very strong pitch forward input from the pilot at the controls leading some perceptual modelers to question whether the unloading event possibly contributed to the initiation of the illusion. **METHODS:** Utilizing black-box data information from several transport and helicopter mishaps we have compared GIF in each category of aircraft. **RESULTS:** Several helicopter mishaps attributed to SMG illusion, based on either survivors' descriptions or voice recorder data, follow the traditional pattern of increased magnitude and rearward shifting of the GIF vector. However, we now present a confirmed helicopter SMG illusion in which the initiating event is an unloading maneuver followed by strong forward cyclic input until impact. **DISCUSSION:** The presented helicopter mishap together with the Atlas Air mishap raises the question of whether the reduced GIF may be a strong contributor to initiating the SMG illusion. Aviation mishaps are frequently associated with acceleration forces that are unable to be replicated on earth-bound acceleration devices. These mishaps contribute to our understanding of illusory mechanisms and modify our perceptual models as well as suggest further in-flight experiments to extend the envelope of perceptual modeling.

Learning Objectives

1. Understand the potential safety risk of the somatogravic illusion in commercial aircraft.
2. Understand that the somatogravic illusion may be subtle and still affect pilot control inputs in not-so-agile aircraft.

[55] CLOSED-LOOP MODELING OF THE SOMATOGRAVIC ILLUSION IN HUMAN-VEHICLE SYSTEMS

Akshay Kothakonda[1], Megan Reissman[2], Timothy Reissman[2], Torin Clark[3], Faisal Karmali[4]
[1]*Massachusetts Institute of Technology, Cambridge, MA, United States;* [2]*University of Dayton, Dayton, OH, United States;* [3]*University of Colorado, Boulder, Boulder, CO, United States;* [4]*Massachusetts Eye and Ear Infirmary, Boston, MA, United States*

(Education - Program/Process Review)

BACKGROUND: Spatial disorientation is defined by incorrect estimation of linear translation, angular rotation, and direction of gravity, posing risk to aviators and astronauts during certain maneuvers. Vestibular organs, located in the inner ear, are a key contributor to the sense of motion. An under-explored cause of spatial disorientation is the difficulty the brain faces in resolving linear accelerations from changes in direction of gravity. In this so-called somatogravic illusion, sustained linear acceleration is misinterpreted by the human controller as tilt, which is implicated in many aviation disasters. Large linear accelerations also occur in spaceflight, and additionally, astronauts may adapt to interpret gravity as linear acceleration. In order to develop countermeasures against these hazards, conditions for, and the extent of, spatial disorientation must first be investigated. **OVERVIEW:** To better understand this hazard, we are developing closed-loop human-vehicle computational models that combine models of human spatial orientation estimation, human motor control and vehicle dynamics. Spatial orientation estimation is modeled using the well-validated "Observer" model, which reproduces many of the errors that occur in human motion perception. These models are being implemented for scenarios such as a high performance aircraft departing a carrier ship using a catapult launch and performing go-around maneuvers. In the case of carrier takeoffs, these models predict that vestibular misinterpretation of large linear acceleration stimuli as pitch tilts relative to gravity results in rapid, incorrect, and dangerous pitch inputs to the vehicle. The human-estimated and actual pitch angle profiles over time under constant linear acceleration show an overall increase and decrease respectively, resulting in descending altitude, in line with known mishaps. **DISCUSSION:** To our knowledge, this is the first closed-loop model of somatogravic illusion that includes models of both the human and the aircraft, and it reproduces known behavior. We expect that these models could assist in developing training for pilots and astronauts to prevent associated mishaps, in accident investigations to explain mishaps, and in developing countermeasures, for example enhancing aircraft systems to detect incipient spatial disorientation. Future work will include incorporating the effect of visual input, and implementing vehicle dynamics associated with a lunar landing vehicle.

Learning Objectives

1. The audience will be able to understand the role of acceleration in spatial disorientation among pilots and astronauts.
2. The audience will get an insight into closed loop modeling of human-vehicle systems, in how it pertains to vestibular functioning.

Monday, 05/06/2024 ***2:00 PM***
Grand Ballroom B

[S-12]: PANEL: AEROSPACE PSYCHOLOGY

Chair: Joe Wood
Co-Chairs: John Heaton, Justin Bunn, Monica Malcein

PANEL OVERVIEW: *TITLE: Aerospace Psychology BODY: This panel presents diverse topics in mental health from clinicians at the Neuropsychiatry Branch of the Aeromedical Consultation Service (ACS). The first presentation outlines the history and evolution of United States Air Force mental health flying standards and discusses current trends. The second presentation is a retrospective epidemiological review examining 620 aviators evaluated by the ACS between January 2018 and September 2023. Next, the diagnosis of obstructive sleep apnea is discussed in detail, including concerns regarding cognitive deficits and mental health symptoms, and recommended neuropsychological evaluation characteristics are provided. Finally, guidance is given for the use of a widely used psychological measure, the Millon Clinical Multiaxial Inventory-IV, when administered in aviation evaluations.*

[56] UNITED STATES AIR FORCE MENTAL HEALTH FLYING STANDARDS: MORE EVOLUTIONARY THAN REVOLUTIONARY

Joe Wood
USAFSAM/ACS, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Mental health flying standards are designed to ensure that aviators who are selected are healthy and remain so. For flyers who do develop a mental health disorder, there is a reliable process to return to flying status. **TOPIC:** Mental health standards are crucial for both the selection and retention of aviators. They ensure that the United States Air Force (USAF) selects highly qualified candidates with less risk for developing duty-impacting psychiatric disorders than the general population. For those who do require treatment for psychiatric conditions, supporting factors for returning to flight status include completion of an empirically-based treatment program, controlled and/or resolved symptoms, low risk of recurrence, and lack of duty impairments or safety concerns. For the USAF, these standards are listed in the Medical Standards Directory, which provides standards for retention, flying classes, and special operational duty. The Aeromedical Waiver Guide (AMWG) adds guidance regarding waivers for aviators who have been diagnosed with a disqualifying condition. It includes summaries of disqualifying diagnoses, waiver potential based on historical data, and requirements for waiver submission. The AMWG, first published in 1993, and updated periodically, originally contained six remarkably concise mental health chapters, most with recommendations for six to twelve month waiting periods post-treatment prior to consideration of a flying waiver. Subsequent updates added chapters on ADHD/Learning Disorders, Eating Disorders, Somatic Symptom and Related Disorders, and Posttraumatic Stress Disorder (PTSD) and contained more delineated guidance. Significant changes occurred in 2012 with the approval of the use of select antidepressant medications while on flying status. Additionally, in the past decade there has been a notable increase in waiver recommendations for conditions, such as PTSD, that were rarely waived in the past. Current issues being discussed in this area include access to care, visibility of treatment documentation, and post-treatment waiting periods. **APPLICATION:** Gaining a historical perspective of flying standards can provide context and guidance for clinicians, flight surgeons, and policy makers considering updating the standards to better fit current preferences and needs.

Learning Objectives

1. The audience will learn about the development of mental health flying standards.
2. Participants will be able to identify recent changes in policy.

[57] UNVEILING PREVALENCE AND TRENDS IN NEUROPSYCHIATRIC CONDITIONS: A 5-YEAR EPIDEMIOLOGICAL ANALYSIS

John Heaton, Joe Wood
USAFSAM, Wright-Patterson AFB, OH, United States

(Original Research)

INTRODUCTION: The evaluation and understanding of neuropsychiatric disorders within the context of U.S. Air Force are of paramount importance to ensure the safety and well-being of USAF pilots and aircrew. In this study, we delve into a comprehensive 5-year epidemiological review conducted at the Aeromedical Consultation Service (ACS), where we assessed the prevalence and examined the evolving trends of neuropsychiatric conditions in individuals seeking a waiver to resume flying. By shedding light on the patterns and prevalence of these conditions, our study contributes to the ongoing efforts to maintain aviation safety while supporting the mental and emotional well-being of Air Force pilots and aircrew. **METHODS:** This study is a retrospective epidemiological review of data retrieved from internal medical records on 620 aviators evaluated by the Neuropsychiatry Branch at the ACS between January 2018 and September 2023 for at least one evaluation (93 individuals have 2+ evaluations). Sample includes 531 (85.65%) male and 89 (14.35%) female aviators. Age ranged from 20.05 to 60.08 years old (mean 35.75). The data reviewed consisted of ICD-10 diagnostic codes, and branch-level coding categories. Aeromedical Information Waiver Guide Tracking System (AIMWTS) was accessed to gain MAJCOM disposition (waiver outcome). **RESULTS:** The top 10 diagnoses or categories observed at ACS evaluations included obstructive sleep apnea (n=212, 34.19%), adjustment disorders (n=126, 20.32%), antidepressant use (n=104, 16.77%), mood disorders (n= 77, 12.42%), phobic and other anxiety disorders (n= 70, 11.29%), traumatic brain injury requiring neuropsychological testing (n=61, 9.84%), posttraumatic stress disorder (n=55, 8.87%), and suicidal behavior (n=32, 5.16%). Waiver rates were consistent with other studies, with 545 (87.90%) aviators receiving waivers, 56 (9.03%) disqualified, and 19 (3.06%) having other outcomes. **DISCUSSION:** The examination of disease prevalence within the population of USAF pilots and aircrew seeking waivers to return to flying status not only provides valuable insights into the health of this specific group but also plays a pivotal role in shaping aviation policies and health protection measures. By identifying prevalent conditions and trends, we can tailor policies and interventions aimed at mitigating risks associated with these disorders and maintaining the overall safety.

Learning Objectives

1. Understand the significance of evaluating neuropsychiatric disorders within the U.S. Air Force context and its direct impact on aviation safety and the well-being of pilots and aircrew.
2. Analyze the findings of a 5-year epidemiological review conducted at the Aeromedical Consultation Service (ACS) to assess the prevalence and evolving trends of neuropsychiatric conditions in individuals seeking waivers to resume flying, with a focus on the unique challenges faced by this specialized population.

[58] NEUROPSYCHOLOGICAL SCREENING IN EVALUATION OF OSA FOR FLYERS

Monica Malcein
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Obstructive sleep apnea (OSA) is a condition which, if left untreated, can have significant aeromedical complications such as excessive daytime sleepiness, heart rhythm disturbances, stroke, hypertension, and cognitive changes. OSA is associated with cognitive dysfunction in the general population, with the the most widely noted deficits including reduced attention/vigilance, memory, visuospatial abilities, and executive functioning in individuals with untreated OSA. Adequate treatment of OSA does appear to improve cognitive

functioning in those who exhibit deficits, although a return to baseline is not always seen. Within the aviation environment, sleepiness, lapses in attention,or decreased executive functioning that may accompany untreated or undertreated OSA, can have significant safety implications. **TOPIC:** Given the potential for changes in cognitive functioning in individuals with OSA, neuropsychological testing is included in the evaluation for some pilots and aircrew seen at the Aeromedical Consultation Service (ACS). While the literature on cognitive dysfunction associated with OSA in the general population identifies deficits in attention/vigilance, memory, and executive functioning, little is currently known about the impact that OSA has cognitive abilities in the aviator population. It is well-established that aviators are a unique population with superior intellectual and cognitive abilities. Neuropsychological screening data from 100 USAF pilots and aircrew personnel that were seen at the ACS for evaluation with sleep medicine (to include PSG, MWT) from 2017 to 2022 were collected as part of the clinical evaluation. The neuropsychological data included measures of intellectual functioning (MAB-II), neurocognitive functioning (MicroCog), and sustained attention (CPT-II). A review of these findings, including a discussion of any change from pre- to post-test for pilots for whom baseline testing was available, relationship of OSA severity to neurocognitive findings, and contribution to aeromedical dispositions will be presented. **APPLICATION:** Neuropsychological deficits associated with OSA have the potential to negatively impact functioning in the aviation environment. This presentation will focus on the potential usefulness of neuropsychological screening in aviators as part of the overall evaluation with sleep medicine and will present findings from a series of evaluations conducted with pilots and other aircrew.

Learning Objectives

1. The audience will understand the impact of obstructive sleep apnea (OSA) on cognitive functioning.
2. The participant will have a greater understanding of assessing cognitive functioning in aviator population.
3. Learners will understand how neuropsychological screening can be implemented in the evaluation process of those with a history of OSA.

[59] PERSONALITY TURBULENCE IN AVIATORS

Justin Bunn
U.S. Air Force, Fairborn, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: King (1994) retrospectively sampled 82 pilots, advanced student pilots, and other aircrew members who had completed the Millon Clinical Multiaxial Inventory (MCMI) as a part of their flight waiver evaluation with the Aeromedical Consultation Service (ACS). Findings reflected base rate elevations on multiple scales, with consideration for maladaptive personality traits, and possible personality disorder. Of note, only one individual was subsequently diagnosed with a personality disorder "not otherwise specified," after completion of a full psychiatric evaluation. This led to consideration of possible over-pathologizing personality traits in the military aviation community that could be considered adaptive in their various crew positions. Almost 30 years later, similar hypotheses were considered in utilizing the Millon Multiaxial Inventory, 4th edition (MCMI-IV) in assessing current AF pilots/aircrew at the ACS. With the possible significant negative impact on AF pilot/aircrew careers due to the potential diagnosis of a personality disorder, consideration must be given to how personality assessments are utilized and interpreted. **TOPIC:** 57 USAF pilots and aircrew with mental health diagnoses were evaluated at the ACS for waiver recommendation. At the time of clinical evaluation, the MCMI-IV was administered as a part of a battery of psychological assessments. This presentation discusses base rate elevations on multiple scales (Turbulent, Compulsive, and Histrionic) and how careful consideration should be given to understanding the personality traits and behaviors associated with these scales. Additional discussion will focus on how to utilize data most effectively from the MCMI-IV with pilots and aircrew in the aerospace environment. **APPLICATION:** This presentation explores the utilization of the MCMI-IV in the clinical evaluation of AF pilots and aircrew. Base rate elevations on specific scales were noted and considered as a part of the comprehensive mental health evaluation. Consideration of these elevations will invite discussion on the need to carefully consider the application of findings from the MCMI-IV in trained pilots and aircrew in a clinical setting. **RESOURCES:** 1. King, R.E. (1994). Assessing aviators for personality pathology with the Millon Clinical Multiaxial Inventory (MCMI). *Aviation, Space, and Environmental Medicine*, 65, 227-231.

Learning Objectives

1. Enhance understanding in utilizing the MCMI-IV in the clinical evaluation of pilots and aircrew with mental health diagnoses.
2. Discuss base rate elevations on specific scales (Turbulent, Compulsive, and Histrionic) when evaluating pilots and aircrew.
3. What to consider in utilizing data from the MCMI-IV in assessing pilots and aircrew with mental health diagnoses in the aerospace environment.

Monday, 05/06/2024 ***2:00 PM***
Grand Hall J

[S-13]: SLIDES: ANTHROPOMORPHIC MEASURES AND METHODS

Chair: Samir Alvi
Co-Chair: Douglas Hamilton

[60] ESTABLISHING BASELINE OLFACTORY PERFORMANCE IN AIRCREW PERSONNEL

Maya Avni[1], Aya Ekshtein[1], Dana Berger[1], Yuval Kozlov[2], Oded Ben-Ari[1]
[1]*Aeromedical Center, Israeli Air Force, Ramat-Gan, Israel;*
[2]*Hebrew University of Jerusalem, Jerusalem, Israel*

(Original Research)

INTRODUCTION: Changes in olfaction are correlated to various medical and cognitive conditions, hence early detection of olfactory decline may prove useful in identifying cognitive deterioration. The evaluation of the olfactory function can be carried out using validated kits. Limited literature exists on olfactory function in aircrew. This study aimed to evaluate and establish normative values of olfaction in young, healthy Israeli flight candidates and cadets. **METHODS:** Medical records of 668 (93% male) flight academy candidates and cadets who underwent routine medical exams at the Israeli Air Force Aeromedical Center (IAF AMC) were analyzed. The mean age was 18±0.6 (range 17-19). The "Burghart sniffin' sticks" Identification test (IT) was used. The IT consists of 16 pens containing various odorous substances that the subject needs to identify with an objective score of 1-16. Objective olfaction scores in addition to subjective ratings of olfaction (on a scale of 1-10), that were completed prior to the IT were collected. This study was approved by the Institutional Review Board. **RESULTS:** IT scores exhibited a normal distribution with a mean of 12.32±1.78, median of 13, and interquartile range of 3, showing no significant gender differences. Participants received 43.3% higher objective scores than subjective ratings, with no statistically significant gender difference. **DISCUSSION:** Based on our results, IT normal values for young flight candidates and cadets were established. With objective olfaction scores having a normal distribution around the mean of 12.32, 95% (2SD) of our population would fall between 8.76 and 15.88. Participants' subjective estimation of olfaction is lower than objective scores. Our subjects scored below the normative data obtained from a larger, healthy population aged 16-35 on the IT. This normative data, derived from a meta-analysis involving 1434 participants across various countries (excluding Israel), indicated a mean IT score of 13.60. This disparity may be explained by the different age ranges and by cultural customs.

Learning Objectives
1. Baseline olfactory assessment can be used to detect otolaryngological medical conditions and can also be used to detect olfactory deterioration over time, which may be related to various cognitive conditions.
2. Cultural norms can influence individuals' ability to recognize specific odors.

[61] BREATH ACOUSTIC ANALYSIS-BASED NOVEL APPROACH TO DEVELOPING A REAL-TIME SENSOR FOR HYPERCAPNIA DETECTION AND MONITORING IN EXTREME ENVIRONMENTS

Archna Bhatia, Arash Mahyari, Ian Perera, Jeffrey Phillips
Institute for Human and Machine Cognition, Pensacola, FL, United States

WITHDRAWN

[62] AEROMEDICAL SUPPORT NEEDS FOR CANADIAN OPERATIONAL MILITARY FEMALE PILOTS

Joelle Thorgrimson[1], Karen Breeck[2]
[1]*Canadian Forces Health Services, Pensacola, FL, United States;* [2]*N/A, Ottawa, ON, Canada*

(Original Research)

INTRODUCTION: Women continue to remain a minority of Canadian Armed Forces (CAF) operational pilots equalling <2% in 2000 and <6% in 2022. Limited research has been completed on the unique experiences and needs of female pilots, however, in 2000 an unpublished internal CAF study examined recruitment, retention, and aeromedical support needs for CAF operational female pilots. This study is now being repeated almost a quarter of a century later to compare the sex and gender specific aeromedical support needs of Canada's military female pilots. **METHODS:** This mixed methods epidemiological study involved semi-structured interviews with all operational female pilots. Interviews included questions from the United States Air Force Aviator Occupational Interest and Concern Questionnaire, a medical questionnaire and medical records review. A community based participatory research approach was used throughout, including several community leaders, who served as advocates and liaisons between the study population and the investigators to ensure accountability to do no harm. **RESULTS:** 50 (57%) of current CAF operational female pilots from 15 different platforms with a wide range of ranks completed interviews. Mean time in the military was 20 years with a range from 11 to 41 years. Mean total flying hour estimation was 2400 hours with a range of 500 to 8500 hours. A review of period health exams showed expected documentation of female specific medical issues, such as birth control use, menstruation history, pregnancy intention and outcomes, occurred less than 50% of the time. Standard preventative health screenings were variable ranging from 100% for breast cancer to 30% for cardiovascular screening. Common lived experience themes included concerns surrounding female specific medical care around potentially career impacting issues like pregnancy and menopause. **DISCUSSION:** This snapshot looks at women's health related medical care and documentation for CAF's female pilots suggesting there is room for improvement. Ensuring optimization of military women's health management and care will help the military to recruit and retain women in general, but military female pilots in specific.

Learning Objectives
1. Current status of health related medical and preventative care for CAF operational female pilots.
2. Community based participatory research approach in a unique aircrew community.

[63] HEIGHT AND BLOOD PRESSURE AS PREDICTORS OF G-LOC RISK IN JET PILOTS: INSIGHTS FROM THE ISRAELI AIR FORCE

Maya Harel[1], Idan Nakdimon[2], Oded Ben-Ari[3]
[1]*The Israeli Air Force Aeromedical Center, Hod Hasharon, Israel;* [2]*The Israeli Air Force Aeromedical Center, Bat Yam, Israel;* [3]*The Israeli Air Force Aeromedical Center, Or Akiva, Israel*

(Original Research)

BACKGROUND: G-induced Loss of Consciousness (G-LOC) is a major physiological challenge for jet pilots. The risk of G-LOC can be mitigated by correctly performing Anti-G Straining Maneuver (AGSM). The aim of this study was to analyze G-LOC cases in the Israeli Air Force (IAF) and identify relevant risk factors. **METHODS:** This was a case-control study that included all G-LOC cases reported in the IAF between 2015 and 2022. Different G-LOC-related parameters were investigated: G level to induce G-LOC, control over the aircraft ("holding the stick"), flying experience, height, blood pressure, incapacitation duration, and preceding symptoms. Each case was matched with a control of the same age and squadron. The Institutional Review Board approved the study. **RESULTS**: There were 15 G-LOC cases that were matched with controls. The average age was 23.4 ± 5.58 years. They were all males. The average height of subjects in the G-LOC group (183.93 cm) was significantly higher than that of the control group (177.47 cm, $p<0.001$). The systolic blood pressure in the G-LOC group (123 mmHg) was significantly lower than that of the control group (128.4 mmHg, $p = 0.03$). G levels to induce G-LOC were significantly higher in aircrew as opposed to cadets and also in subjects that were in control over the aircraft. **DISCUSSION:** The results of this study, albeit performed on a small cohort, align with results that up until now have only been shown within centrifuge studies.

Learning Objectives
1. Understand the physiological parameters correlated to higher G-LOC risk: as height and lower systolic blood pressure.
2. Learn about the effect of flight experience and the ability to control the aircraft over G-LOC risk.

[64] COMPARISON OF 3-D LASER SCANNING ANTHROPOMETRIC TECHNIQUE WITH CONVENTIONAL DIRECT METHOD FOR HEAD AND FACIAL PARAMETERS

Raghunandan Veeranna
DTE GEN Medical Services (Air), New Delhi, India

(Original Research)

INTRODUCTION: Anthropometric measurements of head and face are critical for aircrew helmet and oxygen mask design. The Indian Air Force is equipped with Laser whole-body scanner which enables capture of 3-D image of the head and face. From this 3-D image, anthropometric surface measurements of the head and face can be quantified. These parameters are smaller in magnitude and any deviation from actual measurements critically affect sizing and fitment of aircrew helmet and mask. Hence, there is a need to assess the reliability of the 3-D laser head and face anthropometry by comparing with those measured by direct method. This, in addition to performance evaluation of technical equipment, would also assist in preparation for a large-scale anthropometric survey. **METHODS**: Head and face anthropometric parameters namely, head circumference, head length, head breadth, bizygomatic breadth, nasion menton length, nasion pogonion distance, nose length, nose breadth, ear length, ear breadth and width of mouth were measured for 250 volunteers by direct manual and laser scanning method and compared using Bland-Altman analysis and mean error percentage. **RESULTS**: Using Bland-Altman analysis, the limits of agreement were calculated as mean ± 1.96*SD and expressed as a percentage of the mean manual measurement for all the 12 parameters. Only head circumference, head length, head breadth and nasion-menton length

parameters were found be comparable between the two techniques. The mean error percentage (maximum absolute error percentage) for these parameters were 1.6% (4.5%), 4.5% (12.9%), 7.2% (15.2%) and 3.4% (15.7%) respectively. **DISCUSSION**: Comparison revealed that the laser scanning method produces unreliable results for majority of head and face anthropometric parameters essential for helmet and mask design. Inaccuracy in measurement from laser scan image can be attributed to subjective difficulty and variation in identifying landmarks on the scan image for taking measurements. Considering the small measurements involved, it is recommended to use markers for head and face scanning and to conduct extensive training on identifying landmarks and measuring parameters from the scan image. Separate high resolution laser scanners may also be explored for head and face laser 3D anthropometry.

Learning Objectives

1. The participants will learn that head and face anthropometry using 3-D laser scanner can be unreliable due to subjective difficulty and variation in identifying landmarks on the 3-D head and face image generated by the scanner. Therefore, extensive training on identifying landmarks and measuring parameters is essential.
2. The participants will learn that laser scanner in head and face anthropometry is less reliable for transverse parameters like bizygomatic breadth, nose breadth, ear breadth and width of mouth and more accurate for head circumference, head length, head breadth and nasion-menton length parameters.

[65] MECHANICAL DAMAGE TO THE ANNULUS FIBROSUS FROM CYCLIC LOADING MAY TIE TO NECK AND BACK PAIN ONSET

Jack Seifert[1], Lance Frazer[2], Alok Shah[3], Dennis Maiman[3], Narayan Yoganandan[3], Keith King[4], James Sheehy[4], Glenn Paskoff[4], Daniel Nicolella[2], Timothy Bentley[5], Brian Stemper[1]
[1]*Marquette University and Medical College of Wisconsin, Milwaukee, WI, United States;* [2]*Southwest Research Institute, San Antonio, TX, United States;* [3]*Medical College of Wisconsin, Milwaukee, WI, United States;* [4]*Naval Air Warfare Center Aircraft Division, Patuxent River, MD, United States;* [5]*Office of Naval Research, Arlington, VA, United States*

(Original Research)

INTRODUCTION: Fighter pilots and military helicopter aircrew experience chronic neck and back pain at rates significantly higher than civilians. Their unique loading conditions, including high-G exposures and whole-body vibration, likely contribute to accelerated degenerative changes that can alter the response of the spine to external loads and contribute to spine-mediated pain. This study aimed to characterize mechanical changes to the annulus fibrosus (AF) associated with repeated loading modeling in the military aviation environment. **METHODS**: Fresh porcine AF specimens were used in this study which have been previously identified as representative of human tissue. Test specimens were harvested from the anterior superficial region of the AF and exercised in tension using a protocol that quantified pre- and post-damage stiffness and viscoelastic (i.e., time/rate dependent) properties. Tissue damage was induced using repeated subfailure tension loading with one of nine pre-defined groups with a combination of different strain magnitudes (11%,28%,44%) and cycle counts (400,1600,6400). Damage loading time ranged from 1 to 81 minutes. Following damage and post-damage material characterization, specimens were quasi-statically pulled to failure. **RESULTS**: Stiffness and viscoelasticity of AF tissues decreased significantly after damage loading for all damage groups and changes were correlated with both the magnitude of applied loading and the total number of cycles. Despite significant dose-dependent changes to the viscoelastic and elastic properties, the ultimate properties during quasistatic distraction to failure did not change. This indicates the mechanical response during low-strain magnitudes is significantly affected, but not the high-strain mechanical response. **DISCUSSION**: This study quantified changes in AF mechanics caused by tensile damage loading and found decreases in viscoelastic and elastic properties post-damage. These changes reduce the ability of the intervertebral disc to absorb energy associated with external loads and can contribute to disc laxity, which can lead to spine segmental instability. These changes can increase the loading of the surrounding apophyseal joints and may contribute to discogenic and radicular pain symptoms. These findings may partially explain a mechanism of acute flight-related pain symptoms in military aircrew, highlighting a need to reduce the magnitude of cyclic loads an AF is exposed to during flight.

Learning Objectives

1. The audience will learn how the mechanical response of the annulus fibrosus changes in response to damage caused by cyclic loading.
2. The audience will be able to understand why changes in the mechanical response of the annulus fibrosus may contribute to discogenic and radicular pain symptoms.

Monday, 05/06/2024 ***2:00 PM***
Grand Hall K

[S-14]: SLIDES: PRECISION MEDICINE INNOVATIONS FOR SPACE HEALTH, SAFETY AND PERFORMANCE

Chair: Ian Mollan
Co-Chair: Annette Sobel

[66] RELATIONSHIP MATRIX FOR 'HUMAN RESEARCH FOR CIVILIANS IN SPACEFLIGHT AND SPACE HABITATION' (HRP-C) ROADMAP

Simon Evetts[1], Bettina L Beard[2], Angie Bukley[3], George C Nield[4], Michael Schmidt[5], Annette Sobel[6]
[1]*Blue Abyss, Camberley, United Kingdom;* [2]*NASA Ames Research Center, San Francisco, CA, United States;* [3]*The Aerospace Corporation, El Segundo, CA, United States;* [4]*Global Spaceport Alliance, Alexandria, VA, United States;* [5]*Sovaris Aerospace, Boulder, CO, United States;* [6]*Texas Tech University, Lubbock, TX, United States*

(Education - Tutorial/Review)

INTRODUCTION: The ability to safeguard civilians travelling to/from and spending time in Space requires an international, interdisciplinary effort to efficiently implement the necessary research and operational procedures. A venture was started in 2020 to this end to establish a Roadmap to aid coordination and optimization of precision medicine and multi-omics efforts at an international level. This presentation relates to this panel by developing an effective methodology for application of emerging precision medicine technologies and platforms. **TOPIC:** The venture, termed Human Research for Civilians in Spaceflight and Space Habitation (HRP-C), documents fields of recommended research according to currently known Space hazards and risks. The objective is to describe these fields in sufficient detail to guide international research teams and funding agencies to coordinate the necessary research to support the emerging commercial human spaceflight sector. A matrix has been designed to underpin this work which illustrates the relationships between the categories of hazards, the effects of these hazards, and the impact of the effects on health conditions and disabilities expected to be present in civilians travelling to Space. The matrix once complete will outline the necessary training, preparation, countermeasures and mitigations, where known, required to prevent or minimise such impacts. Gaps in such knowledge will be evident and facilitate future R&D efforts. The necessary information is captured according to Design Reference Missions such as LEO, cis-lunar missions, and Lunar exploration. Outline descriptions of the research study designs, methodology, appropriate platforms, data collection and analysis techniques, and the size and nature of subject populations deemed necessary

to efficiently develop effective mitigations and responses to the adverse impact of spaceflight on civilian human health, will be detailed within the roadmap. **APPLICATIONS:** The ultimate objective of the venture is to facilitate the coordination, optimization and efficiency of research across disciplines and the international human spaceflight community and aligned sectors, to map the civilian Space travellers' comprehensive response to spaceflight, provide a view into how spaceflight influences the health of Spaceflight Participants (as opposed to government astronauts), and to develop the necessary countermeasures so that civilians can travel, live, work, and thrive in Space.

Learning Objectives

1. The audience will understand general gaps in knowledge of space health and research study designs to address those gaps.
2. The audience will become familiar with an approach to relating environmental hazards to health conditions to new mitigation strategies.
3. The participant will understand new approaches to potential precision medicine applications to space medicine.

[67] BUILDING AN ASTRONAUT DIGITAL TWIN: PRACTICAL APPLICATIONS IN PRECISION MEDICINE

Caleb Schmidt[1], Michael Schmidt[1], Tom Paterson[2]
[1]*Sovaris Aerospace, Boulder, CO, United States;* [2]*Embody Biosciences, Corte Madera, CA, United States*

(Education - Tutorial/Review)

INTRODUCTION: Space exploration presents unique challenges to human physiology, necessitating innovative approaches to comprehend and mitigate the health risks and performance issues faced by astronauts. Industries such as aviation and aerospace have successfully implemented virtual digital twin models to understand the real-time performance of engineered systems. The translation of the digital twin paradigm, termed biodigital twins, into biological systems and precision medicine, has been rapidly advancing into areas such as cardiovascular and cognitive health. **TOPIC:** The core of biodigital twin modeling involves quantitatively representing homeostasis using diverse data sources, including published literature, publicly available datasets, and novel data to capture population variability. Since modeling the entire human system is of daunting complexity and, often, intractable, this is achieved by using constrained network approaches that incorporate a reduced number of inputs having the greatest effect size associated with the desired output. Modeling methods include the application of systems of nonlinear differential equations and Bayesian inference. Biodigital twin models streamline the representation of complex interactions, focusing on the relevant subset of an astronaut's molecular phenotype, physiology, behavior, and/or environment for a specific objective (e.g., mitigating issues caused by fluid shifts associated with microgravity). Sources of variation encompass genetic, molecular, physiological, lifestyle-centric, and xenobiotic and environmental factors. **APPLICATION:** The deployment and utilization of biodigital twins is twofold: one goal is to enable precise real-time predictions of health status and performance trajectory during missions. Through simulating changes in microgravity and other spaceflight-associated stimuli, biodigital twins can proactively identify potential health risks and performance issues, optimize countermeasures, and generate precision medicine intervention strategies. A second application views the digital twin through a research lens and can facilitate a unique understanding of novel datasets, uncovering novel mechanisms and patterns for iterative discovery in spaceflight.

Learning Objectives

1. The audience will understand what a biodigital twin is and how it differs from other embodiments of digital twins.
2. The audience will learn the basic underlying principles of biodigital twins, how they can represent homeostasis in biological systems, and how they capture the variability in a population.
3. The audience will learn how biodigital twin models can be deployed clinically for precision medicine applications and for research purposes in a spaceflight environment.

[68] ENHANCING EXPLORATION PLATFORMS AND ANALOG DEFINITION: A PLATFORM FOR MEDICAL DECISION-MAKING, PRECISION, AND PERSONALIZED MEDICINE

Emmanuel Urquieta[1], Jimmy Wu[1], Dorit Donoviel[1], Jennifer Fogarty[2]
[1]*Baylor College of Medicine, Houston, TX, United States;* [2]*Baylor College of Medicine, Houston, Trust Territory of the Pacific Islands, United States*

(Education - Tutorial/Review)

INTRODUCTION: The recent expansion in civilian commercial spaceflight missions brings a new and unique opportunity to understand edge cases and implement precision, and personalized medicine. A new platform has been established to collect data from these unique opportunities: Enhancing eXploration Platforms and Analog Definition (EXPAND) Program. **METHODS:** EXPAND collects biomedical data and bio-samples from commercial spaceflight participants; store the original and processed biomedical, environmental, and mission data in a robust database; and distribute the data to researchers, stakeholders, and government agencies with legitimate scientific inquires. **DISCUSSION:** EXPAND is an all-encompassing program with a biobank that stores samples as well as a space omics protocol. Assay results are stored in the EXPAND database to avoid repeated studies and maximize samples. A variety of biomedical, environmental, and mission data types are ingested. The data access and governance model allows researchers to access and visualize their data quickly and easily. EXPAND has one unified, generic institutional review board (IRB) protocol. A broad single consent form allows the future use of data and bio-samples in compliance with international privacy and medical data use laws. EXPAND has established a set of essential measures to collect data from the highest-priority human spaceflight areas. They standardize the data/biosamples collected and the hardware, training, and procedures for data collection. In the arena of space omics, the platform collects standardized preflight, in-flight, and post-flight bio samples, which include: blood, urine, saliva, fecal and body swabs for microbiome sequencing. On each sample proteomics, metabolomics, single-cell sequencing (RNAseq, Immune profiling), cfDNA sequencing, transcriptomics (RNAseq), and epigenomics are performed. Analyses also include CLIA whole genome sequencing (20X) for clinically actionable pathogenic variants, and pharmacogenomics assays which interrogate various sites in each of the 7 genes known to affect response to many common medications. Gender and age-matched controls are also enrolled to increase the scientific value further. EXPAND has already successfully collected data from Inspiration4, MS-20, Ax-1, Ax-2, and Polaris Dawn. This work is supported by the Translational Research Institute for Space Health through NASA Cooperative Agreement NNX16AO69A

Learning Objectives

1. To understand new opportunities to use medical edge cases in commercial spaceflight.
2. To understand new uses of pharmacogenomics, pathogenic variants, and deep phenotyping in commercial spaceflight for precision medicine use.

[69] ANESTHESIA IN SPACE: PHARMACOLOGY AND PHYSIOLOGY

Robert Fong
University of Chicago, Chicago, IL, United States

(Education - Tutorial/Review)

INTRODUCTION: Conducting surgical procedures in the microgravity environment of space is quite challenging and in general efforts are made to avoid having to do so. However, as the frequency, duration and application of space travel increase moving into the future, the likelihood of needing to perform such procedures, likely on an urgent or time sensitive basis, will increase in parallel. An understanding of the principles of providing safe and effective care in these constrained circumstances

will be increasingly important. Providing an anesthetic to facilitate a surgical procedure requires a customized approach that takes into consideration the individual patient and his or her underlying physiology and comorbid burden; the intensity, anatomic location and invasiveness of the planned procedure, and the preferences of the proceduralist. A variety of anesthetic approaches are available that span a range of patient consciousness and awareness as well as analgesic strategies. The anesthetist's pharmacological toolbox contains a variety of drugs that have varying effects and can be incorporated into a personalized cocktail to provide a safe and comfortable procedural experience for the patient. This discussion will provide an overview of these principles, along with a summary of the pharmacology of the most commonly used anesthetics. The unique environment associated with space travel and microgravity engenders known physiological alterations and significant technical challenges that impact the safe conduct of an anesthetic. A summary of these physiological changes will be provided, along with current thinking regarding anesthetic planning and conduct in this context. **TOPIC:** Physiologic alterations in microgravity

Anesthetic considerations in space environment

Anesthetic pharmacology

APPLICATION: Providing safe and effective procedural anesthesia in space environments

Learning Objectives

1. The participant will be able to summarize the physiologic alterations engendered by microgravity.
2. The audience will learn about the pharmacology of commonly used anesthetic agents.

[70] REGIONAL ANESTHESIA AS AN EFFECTIVE SOLUTION FOR SPACE MEDICAL PROCEDURES

Fayyaz Ahmed
The University of Chicago, Chicago, IL, United States

(Education - Tutorial/Review)

INTRODUCTION: The success of spaceflight missions is increasingly threatened by emergency medical situations, especially as missions venture further from terrestrial medical support. Limited attention has been given to administering safe and effective anesthesia. The likelihood of a medical condition requiring anesthesia is estimated at 2.56%. Administering general anesthesia in microgravity poses numerous logistical and physiologic challenges. However, regional anesthesia could be used to overcome many of these obstacles and provide safe anesthesia and pain relief during deep space missions. **TOPIC:** Regional Anesthesia can provide long-lasting and effective pain relief for a wide range of injuries while maintaining physiologic homeostasis. It can enable astronauts to return to their mission duties more quickly. Regional anesthetic techniques can be adapted to spaceflight with relatively few changes to existing on-Earth protocols. All associated materials for regional anesthesia are compact, highly portable, and non-combustible. Portable ultrasound technology can be used to facilitate regional, which can also provide medical diagnostics. Developing technical expertise in regional anesthesia can be achieved by mastering a limited number of blocks, with an average of 20 procedures required to reach a learning curve plateau. Reasonable upper and lower extremity analgesia could be achieved with three commonly used nerve blocks: supraclavicular, femoral, and sciatic. Trunk and hip coverage can be provided by administering peri-neuraxial or fascial plane blocks since providing neuraxial blockade is not advisable due to unpredictable drug spread. Onboard medical providers can be trained pre-mission to accomplish these technical skills, with onboard support from guidelines and AI-assisted devices like ScanNav Anatomy. **APPLICATION:** The challenge of managing emergency medical situations with anesthesia during prolonged deep space flights can be effectively addressed by relying on regional anesthesia. It is a relatively safe and effective way to manage various conditions, including burns, cellulitis, elbow/shoulder dislocations, upper and lower extremity fractures, and skin lacerations. It will provide a mental cushion for planning emergency medical needs for future missions venturing away from Earth. By mastering essential blocks and techniques, astronauts can be well-prepared to handle medical emergencies in space successfully.

Learning Objectives

1. The audience will learn about the benefits of utilizing Regional Anesthesia as a means to manage the challenges of administering anesthesia in space.
2. The audience will learn about the process of incorporating regional anesthesia tools in space missions.
3. The audience will learn about the common nerve blocks to facilitate regional anesthesia in space and the process to develop technical expertise.

[71] PHARMACOGENOMICS IN SPACEFLIGHT: A FOUNDATION OF PRECISION MEDICINE IN ASTRONAUTS

Michael Schmidt, Caleb Schmidt
Sovaris Aerospace, Boulder, CO, United States

(Education - Tutorial/Review)

INTRODUCTION: Pharmacogenomics is the study of how genes influence an individual's response to medication (gene-drug interaction). In spaceflight, pharmacogenomics is the precise analysis of gene variants that influence the regulation of drug metabolism and the attendant development of therapeutic strategies for spaceflight. Pharmacogenomics represents a technology available today to tailor drug therapy to the individual astronaut, so that the drug countermeasure optimizes the chance for benefit (efficacy), minimizes the chance for adverse events (safety), and limits adverse operational encroachment (performance). **TOPIC:** Pharmacogenomics (PGx) requires the precise molecular analysis of the individual astronaut genotypes of Phase I enzymes, such as CYP450: 1A2, 2B6, 2C9, 2C19, 2D6, 3A4, 3A5, and others. This also includes Phase II enzymes such as glucuronidases, sulfotransferases, glutathione-*S*-transferases, methyltransferases, and others. Practical examples of gene-drug interactions include how tramadol conversion to morphine in astronauts with the CYP450 2D6 ultra-rapid metabolizer phenotype can be accelerated, thus risking safety on an EVA. Astronauts on statins who possess the SLCO1B1 gene variant are at greater risk for myopathy, regardless of dose. The PGx profile allows one to characterize drugs that should be avoided due to lack of efficacy or poor safety. Amplifying the impact of gene-drug interactions in spaceflight are the convergent effects of drug-drug, drug-food, and drug-nutrient interactions. **APPLICATION:** The implication for space missions is of great practical importance today. First, precise personalized drug prescribing profiles can be designed for each astronaut. Second, a crew prescribing profile can be built for each mission, so that flight surgeons have a pre-mission prescribing repertoire from which to operate clinically. Our five-step approach can be operationalized today and scaled across any and all flight operations in any aerospace application. This warrants immediate attention because many types of adverse drug responses are predictable, repeatable, and avoidable.

Learning Objectives

1. The participant will be able to understand the basic features and limitations of pharmacogenomics in spaceflight.
2. The participant will understand a series of basic steps that must be addressed in considering the precision medicine application of pharmacogenomics governing personalization and stratification in practice.
3. The participant will understand the convergence of pharmacogenomics (gene-drug interactions) with drug-drug, drug-food, and drug-nutrient interaction.

Monday, 05/06/2024 ***2:00 PM***
Grand Hall GH

[S-15]: SLIDES: AIR TRANSPORT: TRIALS AND TRIBULATIONS

Chair: Tarek Sardana
Co-Chair: Melchor Antunano

[72] EUROPEAN AIR TRANSPORT COMMAND AND MULTINATIONAL MRTT UNIT - A NOVEL EUROPEAN COOPERATION IN THE FIELD OF STRATEGIC AEROMEDICAL EVACUATION

Martin Gascón, Adolfo Simonetti, Erwan Dulaurent, Anne Schenk, Ralph Vermeltfoort, Alessandro Fiorini, Frank Lamers, Wagner Stephan, Matthieu Gaboriaud, Mathias Borsch
European Air Transport Command, Eindhoven, Netherlands

(Original Research)

INTRODUCTION: European Air Transport Command (EATC) is an integrated command of 7 nations and among its core capabilities is that of Strategic Aeromedical Evacuation (StratAE). 6 European partners participate in the Multinational MRTT Unit (MMU), which consists of 9 A330 MRTT aircraft. One of them is utilised as an AE asset on 24-hour notice-to-move standby. The cooperation between the two entities started in June 2023. **MATERIAL AND METHODS:** The new collaboration between the two multinational entities in the field of StratAE and its impact on current procedures was analysed based on number and characteristics of patients and executed missions from July till October 2023. **RESULTS:** 7 patients were transported in 4 missions. 4 of them were from Germany and 3 from the Netherlands. Both countries belong to both EATC and MMU. Neither death nor disease contagion were reported during the AE performances. Priority 3 cases were 5, the 2 remaining were classified as Priority 2. Dependancy 2 was stated in 4 of 7 cases. Niger, Norway, Poland and Spain were the countries of origin. Patients' diseases included rectal bleeding, long QT syndrome, spontaneous pneumothorax and 2 traumatological cases. In all cases the aircraft used was the StratAE version of the Airbus A330 MRTT based in Cologne. **CONCLUSIONS:** Since the asset is Dutch, the medical crew is German and the patient can be from a different nation, cooperation between EATC and MMU represents a challenge in terms of multinational environment, language barriers and harmonization of medical equipment, among others. With seven patients transferred, it has proven to be a safe and effective means of transportation, however, there is still room for improvement regarding standardization and smoothing procedures.

Learning Objectives

1. The audience will learn about EATC and MMU as two multinational entities involved in StratAE.
2. The audience will learn about the benefits and challenges to StratAE missions resulting from the cooperation between EATC and MMU.

[73] MODELING THE IMPACT OF FLIGHT CONDITIONS ON PULMONARY FUNCTION IN TRANSPORTED CASUALTIES TO FACILITATE FUTURE UNMANNED CASEVAC SAFETY

Bria Morse[1], Michael Tibbs[1], Lonnie Petersen[1], Casper Petersen[2]
[1]*Massachusetts Institute of Technology, Boston, MA, United States;*
[2]*Harvard University, Boston, MA, United States*

(Original Research)

INTRODUCTION: It is anticipated that commanders will want to reduce the risk to personnel in future military theaters by employing unpiloted aerial vehicles (UAV) in combat zones. Evasive maneuvering required for casualty evacuation in contested environments can expose patients to flight conditions and forces that put their health at risk. Pulmonary function is highly susceptible to gravitational impact. Although it is known that hypergravity and hemorrhagic blood loss are factors that can independently lead to atelectasis, the combined and potentially synergistic impact of these two factors remains unknown. This study aimed to assess the feasibility of developing pulmonary models to identify threshold values for when hemorrhagic patients begin having difficulty tolerating gravitational G-force-related stress. **METHODS:** The study was approved by the AFRL IRB. Six healthy volunteers (two female, age 33±10 years) were placed supine inside the centrifuge. Moderate hemorrhage was simulated by -20 mmHg LBNP. Evasive maneuvers were simulated by 15-sec +4Gx acceleration in isolation and in combination with LBNP. Electrical impedance tomography (EIT) (Enlight 2100, Timpel Medical, Brazil) was used to measure changes in ventilatory distribution at the 4th and 5th intercostal spaces. **RESULTS:** LBNP alone had limited impact on air distribution within the lungs, while the +Gx-only condition contributed to a shift in ventilation towards the anterior portion of the lungs. However, the data indicate that the combination of +Gx and hemorrhage further exaggerates the lung's uneven posterior and anterior air distribution. **DISCUSSION:** The data suggests that supine exposure to +Gx elicits a disturbance in the lung's ventilation-perfusion relationship. The apparent further exacerbation of this mismatch in simulated hemorrhage conditions should be considered in future models used to create safe and robust autonomous flight-restraint systems for UAV-CASEVAC.

Learning Objectives

1. Evasive flight maneuvers (steep bank) can lead to uneven air distribution in the lungs, increasing the risk of atelectasis for patients with mild/moderate blood volume loss.
2. To aid in the initial investigation of mapping physiological data to suitable flight envelopes and trajectories.

[74] ROYAL FLYING DOCTORS SERVICE – TOWARDS 100 YEARS OF AEROMEDICAL EVACUATION AND REMOTE TELEHELTH.

Meg O'Connell
Royal Flying Doctors Service- Queensland, Cairns, Australia

(Education - Program/Process Review)

BACKGROUND: The Royal Flying Doctors Service (RFDS) is one of the world's oldest and largest aeromedical organisations, focused on aeromedical evacuation and remote telehealth. Over the past 96 years, healthcare has been delivered by necessity across extreme distances and challenging circumstances, supporting remote indigenous communities, ranger stations, isolated towns, islands, rural nurses and ships at sea. As fuel costs and pilot shortages continue to impact operations, a critical services review identified ways to pivot to augment healthcare delivery with virtual health, remote patient monitoring, telepharmacy and UAV pharmacy delivery to better deliver healthcare with less aircraft utilisation. **OVERVIEW:** This presentation aims to both highlight the important historic contributions of the RFDS to aerospace medicine, but also prepare for the future as we continue to advance our health care delivery to best meet the needs for remote and isolated patients whilst encountering aviation challenges. Pivoting from face to face, fly in, fly out healthcare delivery to a stronger focus on telehealth and virtual health has reduced costs for both patients and the organisation, and enabled more efficient healthcare delivery. A range of organisations was reviewed, including international space station healthcare operations, to identify new ways of working to employ. **DISCUSSION:** The creation of virtual clinics, virtual communities and virtual wards has allowed for multi day and planned episodes of care delivery via telehealth, and subsequently reduced the need for aeromedical evacuation in a significant cases. An organisational pivot from on demand reactive healthcare, to planned virtual proactive healthcare, is a key future focus to improving the healthcare of remote patients and reducing the need for aeromedical evacuation. Finally the difficulties of delivering this type of care in remote and resource limited settings are discussed, and how technology, like UAV is planned to be utilised to overcome these challenges.

Learning Objectives
1. Understand the operations of a large state based remote medicine service, and identify new ways of delivery healthcare to remote patients.
2. Explore virtual healthcare as a way of delivering multi-day episodes of care and preventative care to reduce cases resulting in aeromedical retrieval.
3. Understand new was of augmented healthcare delivery for an aeromedical organistion, including augmented virtual care, remote patient monitoring, telepharmacy, UAV medication delivery and virtual clinics to meet the needs of remote patients.

[75] UNITED STATES AEROMEDICAL EVACUATIONS FROM ANTARCTICA FROM 2015-2023: A RETROSPECTIVE REVIEW OF MILITATY AND CIVILIAN DATA

Jay Rathod[1], Dan O'Conor[1], James McKeith[2], Craig Nowadly[3]
[1]*Brooke Army Medical Center, San Antonio, TX, United States;* [2]*UTMB, Galveston, TX, United States;* [3]*59th Medical Wing/Brooke Army Medical Center, San Antonio, TX, United States*

(Original Research)

INTRODUCTION: While the primary mission of United States operations in Antarctica is scientific discovery, the Department of Defense (DOD) provides permanent support to the National Science Foundation (NSF) through Operational DEEP FREEZE. One of the major responsibilities of the DOD is to provide logistics and transport capability to the continent, including medical evacuation. Due to logistical challenges, an attempt to comprehensively analyze U.S. aeromedical evacuations from Antarctica, reconciling both civilian and military records across multiple deployment seasons, has not been described in the literature. **METHODS:** This study was approved by the 59th Medical Wing Institutional Review Board. De-identified aeromedical evacuation records involving a patient within/from Antarctica or labeled "Operation Deep Freeze" was obtained from the DOD TRAC2ES database. NSF records were reviewed in person by DOD medical extractors at the University of Texas Medical Branch (UTMB) Center for Polar Operations. De-identified medical data was extracted, including relevant medical history, diagnosis, medical treatments, destination, and en-route care interventions. Twenty percent of UTMB records were reviewed by both extractors for intra-rater reliability. A third extractor reconciled discrepancies as needed. **RESULTS:** 71 DOD TRAC2ES records and 93 UTMB records were included in the final analysis. A preliminary review identified a total of 129 distinct patient movements for calendar years 2015 – 2023. Only 35 records (27.1%) could be reconciled between TRAC2ES and UTMB as the same patient movement. Of the remaining patient movements, 36 were unique TRAC2ES records (27.9%), 58 were unique UTMB records (45.0%). Musculoskeletal pathology (28.9%), genitourinary/reproductive (12.5%), gastrointestinal (14.1%), cardiac (11.7%), and neurologic (9.4%) pathologies were the most common body systems requiring aeromedical evacuation. **DISCUSSION:** These results show that the NSF, DOD and, UTMB work cooperatively to safely transport patients with a wide variety of medical pathologies out of Antarctica. This project highlights the limitations of retrospective chart reviews, especially those requiring data extraction from paper charts and deidentified databases. This knowledge will facilitate immediate follow-on studies to further analyze trends of medical capabilities in Antarctica.

Learning Objectives
1. Understand the differences between DOD and NSF records from Antarctica patient movements.
2. Understanding the trends of United States aeromedical evacuations from Antarctica between 2015 and 2023.
3. Understand the limitations of a retrospective chart review and the next steps planned for data extraction involving United Sates Antarctica medical care.

[76] LESSONS LEARNED DURING A MILITARY AEROEMEDICAL EVACUTION OF A REMOTE CIVILIAN HOPSITAL THREATENED BY FOREST FIRES

Maj Laura Devlin[1], Maj Melissa Gear[2], Maj Richard Grainger[3]
[1]*Canadian Armed Forces, Trenton, ON, Canada;* [2]*Canadian Armed Forces, Winnipeg, MB, Canada;* [3]*Canadian Armed Forces, Victoria, BC, Canada*

(Education - Program/Process Review)

BACKGROUND: Summer 2023 was an unprecedented forest fire season in Canada. Mid-august, the city of Yellowknife, North West Territories, was evacuated due to fast spreading fires threatening the community. 68 inpatients remained in the local hospital, and the closest receiving facility was >1500 km by road. There was no Canadian civilian agency capable of transporting this volume of patients in a short time frame. The Canadian Government requested the assistance of the Canadian Armed Forces to evacuate by air an unknown number of inpatients > 2000 km to the city of Vancouver. **OVERVIEW:** The Canadian Forces Aeromedical Evacuation (CF AE) flight is based in Trenton, Ontario and has the mandate of providing strategic aeromedical evacuation to CAF members anywhere in the world. Care or transport of civilians is only provided if requested and approved by the Minister of National Defence. The Royal Canadian Air Force (RCAF) does not have dedicated AE aircraft and instead uses a platform of opportunity. The vastness of Canadian geography creates a tyranny of distance, and in this case, the providers and aircraft were located 5000km from the area in need. With careful but quick consideration of aircraft, crew composition and size, equipment, load plan, communication and coordination, a crew was launched for the remaining 39 patients (23 stretcher, 6 wheelchairs, 10 ambulatory). The CC177 departed CYZF with all patients less than 36 hours after the initial request was approved. **DISCUSSION:** This was the first time the RCAF and CF AE flight conducted a mass civilian hospital evacuation. Serendipitously, these groups had just participated in Mobility Guardian 2023 and had exercised some larger scale, interoperable, unregulated evacuations. Lessons learned for discussion include; importance of a liaison officer and unrestricted comms between sending, transporting and receiving facility; integration of military and civilian care teams; prolonged care requirements to include medication administration and hygiene; ramp access for medical transport and medical teams; and aircraft equipment to facilitate load plan. It is hoped that the lessons learned during this event can be of use to other organizations who may be required to preform a similar task in the future.

Learning Objectives
1. The audience will understand planning factors which are of importance during large-scale time-bound aeromedical evacuations.
2. The audience will explore the potential challenges and considerations when integrating military and civilian care teams/facilities for joint missions.

[77] UAV FOR CASUALTY TRANSPORT: QUANTIFYING REDUCTION IN G-TOLERANCE IN HEMORRHAGIC PATIENTS

Lonnie Petersen[1], Bria Morse[1], Michael Tibbs[1], Casper Petersen[2]
[1]*Massachusetts Institute of Technology, Boston, MA, United States;* [2]*Harvard University, Boston, MA, United States*

(Original Research)

INTRODUCTION: Future CASEVAC will likely include Unpiloted Aerial Vehicles (UAV) for casualty-transport (drone-ambulances) from combat-zones. Elimination of human-in-the-loop with regards to pilot and medical personnel to monitor flight-impact on patients increases the risk of inadvertent unsafe flight maneuvers. It is presumed that G-tolerance is reduced in casualty, particularly relative to blood-loss, however, we have no physiological data to quantify this reduction. We used long-arm human centrifuge to simulate evasive flight maneuvers (+Gx) and a custom-built lower body negative pressure (LBNP) device

to simulate hemorrhage in a controlled and reversible way. **METHODS:** The study was approved by the AFRL IRB. Six healthy volunteers (two female, age 33±10 years) were placed supine inside the centrifuge. Moderate hemorrhage was simulated by -20 mmHg LBNP. Evasive maneuvers were simulated by 15-sec +4Gx acceleration in isolation and in combination with LBNP. Mean arterial pressure (MAP) and stroke volume (SV) were collected using Nexfin (BMEye). Delta values were analyzed using RM-ANOVA and Šídák's multiple comparisons test. **RESULTS:** Blood pressure was not reduced by LBNP alone (DMAP= -3.4±7.4 mmHg; P=0.8). +Gx alone significantly reduced MAP (DMAP= -19.4±11.4 mmHg; P<0.0005), and when +Gx was combined with LBNP, the reduction was exacerbated (DMAP= -36.1±5.2 mmHg; P<0.0001). Thus, synergistic effect of hemorrhage and G-load significantly reduced MAP compared to either intervention in isolation, absolute value of MAP during LBNP+Gx was 58.5±24.5 mmHg. Neither LBNP nor Gx in isolation decreased SV significantly (DSV= -6.8±6.3 mL; and -8.4±11.6 mL; P>0.05), however, combined effect of LBNP+Gx significantly reduced SV (DSV= -24.2±13.0 mL; P=0.0019). Synergistic effect of hemorrhage and G-load reduced SV to an absolute value of 78.0±19.4 mL. **DISCUSSION:** These data indicate a synergistic effect between +Gx maneuvers and simulated hemorrhage which was significantly more pronounced than either intervention in isolation. Understanding and quantifying G-tolerance of casualties is critical to create safe autonomous flight-restraint systems for UAV-CASEVAC.

Learning Objectives

1. Evasive flight maneuvers (steep bank) simulated by short periods of +4Gx can lead to severe reduction in MAP in patients with mild/moderate blood volume loss.
2. Qualitative and quantitative mapping of physiology is critical to develop suitable flight envelopes and trajectories.

Monday, 05/06/2024 ***2:00 PM***
Grand Hall I

[S-16]: SLIDES: AND THE BEAT GOES ON AND ON!

Chair: Peter Lee
Co-Chairs: Eddie Davenport

[78] THE HEART OF AVIATION: A FITNESS FOR DUTY LITERATURE REVIEW AND COHORT ANALYSIS

Wiaam Elkhatib[1], Thomas Flipse[2], Leigh Speicher[2], Hanna Sledge[2], Zhuo Li[2], Shahyar Gharacholou[2]
[1]*Mayo Clinic Rochester, Rochester, MN, United States;* [2]*Mayo Clinic Jacksonville, Jacksonville, FL, United States*

(Original Research)

INTRODUCTION: The aviation environment imparts unique stressors which increase medical incapacitation risk, with metabolic and cardiovascular disease remaining a leading cause in pilots. Delineating the current status of cardiovascular health and outcomes informs screening protocols, health policy, and fitness for flight duty. Airline pilots are hypothesized to be healthier than the general population from a cardiovascular perspective due to relatively increased health screenings. **METHODS:** A literature review via Scopus, PubMed, Google Scholar, and Web of Science electronic databases through October 1st, 2023, with citation mining was conducted to assess objective cardiovascular screening outcomes and disease prevalence among aviators. An adult pilot cohort undergoing cardiac screening was also retrospectively identified via medical record review at a high-complexity referral facility between 1991 to 2023 for statistical descriptive analysis of demographics, comorbidities, screening and diagnostic tests. Of 364 pilots, 212 (193 male) met inclusion criteria. Kaplan-Meier models were generated for major adverse cardiovascular events (MACE). IRB approval was obtained. **RESULTS:** Less than 20 studies investigated objective cardiometabolic disease measures with variable parameters reported and none were found to report diverse cardiac screening test outcomes with cardiovascular events in a large cohort. The sample included majority commercial airline pilots having a mean age 59 years, median BMI of 27, comorbid hyperlipidemia (48%), hypertension (32%), cancer (27%), sleep apnea (15%), arrhythmia (12%) and coronary disease (6%). Echocardiograms (N=57) revealed valvular disease (21%) and dilated aortas (16%). Functional stress tests (N=118) showed mean aerobic capacity of 109% reaching 12 METS with <7% abnormal. Two left heart catheterizations (N=6) required percutaneous intervention. MACE incidence was 22% (15% excluding non-cardiac hospitalizations). **DISCUSSION:** Airline pilots have similar comorbid disease prevalence and cardiometabolic characteristics compared to published general population evidence including Center for Disease Control data. BMI and aortic dilatation are higher than average. Cardiovascular fitness remains favorable. Ongoing study seeks to incorporate predictive artificial intelligence and cross-matched institutional cohorts for stronger comparisons and outcome predictions.

Learning Objectives

1. The audience will learn about disease distributions and outcomes of special populations which help inform medical screening protocols, public health policy, and fitness for duty.
2. The audience will understand that pilots generally have multiple cardiovascular comorbidities with favorable cardiovascular fitness.

[79] A SINGLE HEART

Tim Sprott, Sarita Dara, Claude Preitner
Civil Aviation Authority New Zealand, Wellington, New Zealand

(Education - Case Study)

INTRODUCTION: This case report describes a commercial civilian helicopter pilot who had incidental findings that lead to a diagnosis of hypertrophic cardiomyopathy (HCM). **BACKGROUND:** HCM is a common disorder, generally agreed to be present at a rate of at least 1:500 in the general population. The clinical course of HCM is variable and there is a spectrum of low to high risk for adverse cardiac outcomes. The potential risks of aeromedical significance associated with this condition include sudden cardiac death (SCD) and ventricular arrhythmias, as well as non-sudden cardiac events such as atrial fibrillation with associated stroke risk, and syncope. For these reasons Regulators apply restrictions especially on single pilot commercial operations. **CASE PRESENTATION:** The subject pilot was a 50-yr old New Zealand asymptomatic AS 350 pilot with 5310 flying hours involved in single pilot scenic and commercial flying. A diagnosis of HCM was made in 2021 following cardiac investigations, including cardiac MRI. He was recertified with a restriction from single Class 1 (commercial) flying. In 2023 he applied for this restriction to be lifted to allow for single pilot Class 1 operations. **DISCUSSION:** The assessment of his aeromedical risk was undertaken taking his risk of SCD, as well as non-sudden cardiac events including atrial fibrillation. In this pilot's case the estimated risk of cardiac related acute medical incapacitation was about 1% or less. This presentation outlines this risk assessment process that led to the decision to lift the restriction on single pilot operations.

Learning Objectives

1. HCM may present from incidental case finding to severe symptomatic disease. The progression of HCM is highly variable as are the risks for adverse cardiac events.
2. SCD risk • Prior cardiac arrest or ventricular arrhythmias • Family history of first-degree or close relative.
3. Evaluating the risks of adverse cardiac events is challenging and well recognised with HCM. For this reason Regulators apply restrictions especially on single commercial operations. There is a subgroup of people living with HCM were the risk is at or below 1% for an adverse cardiac event. In this group this presentation outlines the rationale for considering single pilot commercial flying in this group.

[80] DILATED CARDIOMYOPATHY IN A COMMERCIAL PILOT: A CASE REPORT

Alexandra Mejía-Delgado[1], Johana Giraldo-Alzate[1], Diego García[2], Nohora Inés Rodríguez[3]
[1]*Colombia Civil Aviation Authority/National University of Colombia, Bogotá, Colombia;* [2]*National University of Colombia, Bogotá, Colombia;* [3]*The Colombian Hearth Association - Aerocivil/Civil Aviation Authority of Colombia, Bogotá, Colombia*

(Education - Case Study)

INTRODUCTION: This case study evaluates the impact of dilated cardiomyopathy (DCM) on the aeromedical fitness assessment of an airline transport pilot. Following a history of reduced ventricular function exacerbated by COVID-19 myocarditis, the pilot underwent treatment and safely resumed flying duties through an evidence-based aeromedical decision process. **BACKGROUND:** Cardiomyopathies are disorders of the heart muscle caused by dilated, hypertrophic or restrictive pathology. DCM is defined as a heterogeneous spectrum of myocardial disorders characterized by ventricular dilation and myocardial functional impairment in the absence of hypertension, valvular disease, ischemic or valvular heart disease. More commonly seen in men, prevalence is estimated at 36/100,000 cases. American consensus classifies DCM as genetic, mixed, or acquired, while Europeans group DCM as familial or non-familial. Patients have significantly increased cardiac mass with myocyte enlargement, leading to ventricular dilatation and systolic dysfunction. Diagnosis is made with 2-dimensional echocardiography. Progression and prognosis depend on ejection fraction decay and etiologic factors. Negative prognostic factors include advanced NYHA classification, male sex, severe congestive heart failure, and renal failure. **CASE PRESENTATION:** A 47-year-old male airline transport pilot with 5000 hours of flight experience, with electrophysiological evaluation within normal limits. In June 2022 was diagnosed with myocarditis related to mild COVID-19. During his medical certificate renewal, a slightly dilated left ventricle with diffuse hypokinesia and severe systolic dysfunction LVEF 38% was documented. Optimized therapy for heart failure was started with adequate response. Since September 2022 he has presented a stable improved ejection fraction >50% and he has remained asymptomatic. **DISCUSSION:** The aeromedical group of the Colombian Civil Aviation Authority assessed this case using an evidence-based approach with aeromedical risk-management tools in compliance with ICAO provisions and considerations for a special issuance with a dual-crew restriction. Semestral cardiovascular function is being closely monitored. With cardiology follow-ups including NYHA re-classification, electric instability studies, cardiac function assessments, specific biomarkers measures and continued etiological studies. This case illustrates a safe pathway to aeromedical certification for moderate heart dysfunction.

Learning Objectives

1. The audience will be able to understand how the medical advances play a role to change the aeromedical considerations about fitting to fly.
2. The audience will be able to understand the aeromedical approach and accepted risks assessments are accepted in the decision process.

[81] AN INVESTIGATION INTO THE VALIDITY OF SPORTS WEARABLES FOR HEART RATE MONITORING IN GENERAL AVIATION

Aiden Coffey[1], Pete Marston[2], Ross Pollock[1], Robert Harrison[3], Shafik Diwan[1], Samyukta Ravisankar[1], Alfred Olugbenga[1], Irene Di Guilio[1], Peter Hodkinson[1]
[1]*Kings College London, London, United Kingdom;* [2]*Martin-Baker Aircraft Company Ltd., London, United Kingdom;* [3]*Cranfield University, Cranfield, United Kingdom*

(Original Research)

INTRODUCTION: Aircrew physiological monitoring (PHYSMON) is an area of increasing interest, but published research in general aviation related to this topic is limited. This study held two aims; to describe the heart rate (HR) response of inexperienced fliers to the general aviation environment and investigate the viability of two PHYSMON technologies to measure HR accurately and reliably in general aviation (including aerobatic flight). **METHODS:** 14 subjects with <5 hrs of light aircraft flight experience were passengers during a varied flight profile, including aerobatic manoeuvres, in a T67 Firefly with a flight instructor as pilot in command. Subjects HR was measured by two independent devices; a Garmin Fenix 6 Pro smartwatch utilising photoplethysmography (PPG) and Polar H10 chest strap using electrocardiography (ECG), the latter of which being treated as the reference device. The data was synchronised against cockpit video and analysed for agreement and variance in discrete phases of flight, categorised as either aerobatic or non-aerobatic. **RESULTS:** The two devices were largely in agreement during non-aerobatic flight (bias = 0.2031 with SD = 4.234, LoA -8.501 to 8.095). In aerobatic manoeuvres, the agreement between the two devices decreased (bias = 3.364 with SD = 5.371, LoA -7.163 to 13.89). Short (<10 seconds) duration increases in HR detected by the H10 were often not detected by the Garmin watch, reflected in a higher variance in HR from the H10 during these phases of flight. **DISCUSSION:** The agreement between the H10 and Fenix 6 suggests that PPG technologies work in the assessment of heart rate during non-aerobatic flight. The increasing disparity between chest-strap and smartwatch values for HR in the aerobatic phase suggests that ECG-based devices are more appropriate for use in aerobatic flight. This study highlights the need for PHYSMON devices to be validated in the flight setting to ensure the collected data reflects the physiological reality and suggests that PPG may be unreliable for use in the dynamic flight environment of aerobatics. Alternative technologies may exist for this role that pose novel solutions.

Learning Objectives

1. The audience will learn about the difference in performance between ECG and PPG-based physiological monitoring devices when used in the dynamic flight environment.
2. The audience will learn about the heart rate response to civilian aerobatics.

[82] INTERMITTENT MONITORING OF CARDIOVASCULAR HEALTH VIA INTELLIGENT & REMOTELY OPERATED ROBOTIC CARDIAC ULTRASOUND SYSTEM FOR SUPPORTING FLIGHT SURGEONS

Amanda Spilkin[1], Ehsan Zakeri[1], Hanae Elmekki[1], Ahmed Alagha[1], Hani Sami[1], Antonella Mariel Zanuttini[2], Lyes Kadem[1], Jamal Bentahar[1], Wen-Fang Xie[1], Phillippe Pibarot[2]
[1]*Concordia University, Montreal, QC, Canada;* [2]*Quebec Heart and Lung Institute, Quebec City, QC, Canada*

(Original Research)

INTRODUCTION: Human spaceflight is associated with numerous cardiovascular risk factors. Amongst them, prolonged exposure to microgravity reduces the workload imposed on the human heart and results in long-term structural changes. With space missions growing longer and more unchartered, and limitations on physician assignment in each mission, the use of a remotely operated robotic cardiac ultrasound system (RORCUS) provides an attractive solution for adaptable monitoring of crew cardiovascular health. **METHODS:** The RORCUS was tested to perform a full cardiac ultrasound (US) procedure, scanning four main cardiac windows upon a cardiac phantom torso. The system consists of a six degrees of freedom collaborative robotic arm equipped with force sensors and an ultrasound probe attached to the robot's end-effector. The robotic system was used to build a dataset of US images across the Parasternal Long-Axis, Parasternal Short-Axis, Subcostal, and Apical4Chamber views while maintaining safe physical coupling. The dataset images were graded according to a cardiologist-approved grading scheme. The RORCUS was trained on the labeled dataset using two deep learning models (based on ResNet-18); the first one classified images into one of

the cardiac views, while the second model estimated the quality of the image. The system aids the operator in performing the cardiac US by automatic characterization of cardiac windows and providing information on the quality of the scan. **RESULTS:** Performance in US recordings was evaluated upon the ability of the RORCUS to capture the required data upon the phantom. To assist the remote sonographer, the trained model took the US images in real-time and returned the category of the cardiac windows and the image quality percentage. The deep learning models for cardiac view classification and quality estimation demonstrated effectiveness in view classification and quality assessment according to the pre-defined grading scheme. **DISCUSSION:** The results obtained with the RORCUS demonstrates the ability for a robotic system to perform a full cardiac US examination with high quality images. Flight surgeons can obtain higher quality images and more consistent data from the crew during spaceflight, which in turn, can help in general health monitoring, diagnostics and pathology evolution.

Learning Objectives

1. The participant will learn how the use of an intelligent and remotely operated ultrasound robotic system for crew's cardiovascular imaging can provide flight surgeons with the ability to monitor health and long-term impact of spaceflight on the heart.
2. The participant will learn about a new cardiologist-approved cardiac image grading scheme that can be used for evaluating ultrasound image quality and accurate capture of cardiac windows.

[83] A SHOCKING EXPERIENCE - IMPLANTABLE CARDIAC DEFIBRILLATORS AND FLYING

Anthony Hochberg
Civil Aviation Safety Authority, Sydney, Australia

(Education - Case Study)

A private pilot in late July 2022, after flying then pulling the aircraft into a hangar and while washing it, became pre-syncopal then collapsed in cardiac arrest due to ventricular fibrillation (VF). This event would have been fatal if not for prompt resuscitation by an off-duty paramedic who administered 2 shocks from an automatic external defibrillator.

Subsequent cardiac investigation did not reveal a specific cause for VF – "idiopathic" VF. When a reversible cause of VF is not found, there is high probability of recurrence with unpredictable timing. Accordingly an ICD was implanted to enable continuous automatic detection of these heart rhythms and commit as required appropriate electricaltherapy of VF and ventricular tachycardia (VT) – secondary prevention of sudden cardiac death. That therapy is intended: 1. to treat VT with anti-tachycardia pacing (ATP), thus potentially avoiding the need for shock(s) from the ICD; should the ATP regime fail or reach its programmed time-out, shock(s) will proceed 2. to treat very fast VT or VF with shock(s) In an individual with an ICD, during VT the patient will develop symptoms of the arrhythmia itself or from ATP triggered by VT, ranging from distraction at minimum to pre-syncope or syncope. VF will be completely incapacitating, causing syncope and shock delivery (itself incapacitating), not necessarily in that order. The first appropriate shock may not be effective because of the probabilistic nature of defibrillation of VF. ICD therapy has its problems. Inappropriate therapy may occur because of:

- inappropriate programming
- limitation of software algorithms which discriminate VT or VF from non-ventricular rhythms, such as atrial fibrillation (AFIB) or atrial flutter (AFLT). Mr Cochrane is at higher risk of developing AFIB or AFLT because of his past history of hypertension, mitral valve disease and its associated surgery.
- ATP can accelerate VT into VF with resultant shock delivery
- Hardware failure, for example lead failure
- Environmental electromagnetic interference, detected by the ICD as VF

This presentation reviews the annual risk of incapacitation, risk of recurrent cardiac arrest, risk of defibrillation, impact of age on risk assessment and why it makes risks higher, the impact of ICD appropriate/inappropriate and failure to shock has on flying skills and recovery time, risk to any potential co-pilot of shock and global perspective of other authorities of ICD in pilots.

Learning Objectives

1. Annual risk of incapacitation with idiopathic VF, risk of recurrent cardiac arrest, risk of ICD defibrillation.
2. Limitations ICD therapy including impact of age on risk assessment.
3. Impact of ICD appropriate/inappropriate and failure to shock on flying skills and recovery time, risk to any potential co-pilot of shock and global perspective of other authorities of ICD in pilots.

Monday, 05/06/2024 ***4:00 PM***
Grand Ballroom CD South, EF

[S-17]: PANEL: SENSORIMOTOR STRATEGIES FOR EXPLORATION SUCCESS ACROSS DIFFERENT ARTEMIS MISSION PHASES

Chair: Scott Wood
Co-Chairs: Eric Groen

PANEL OVERVIEW: *Alterations in sensorimotor processing during spaceflight can lead to motion sickness, spatial disorientation, and decrements in postural control, locomotion, and fine motor control during and following G-transitions. These adaptive changes combined with other physiological changes can have functional impacts in critical mission tasks such as manual control, capsule egress and extravehicular activities (EVA). This panel will describe the sensorimotor research strategies to accommodate the needs of the crew and effectively leverage the human capabilities to ensure mission success during planned Artemis missions. The first presentation will provide an overview of the evidence for the sensorimotor risk and research roadmap. The second presentation will provide an overview of how ground-based analog for G-transitions can be used to prepare for the mission as training and research testbeds. The third presentation will describe how research conducted during International Space Station missions will be used to explore on-board training as a potential countermeasure for manual control of lunar landings. The fourth presentation will review the development of sensorimotor assessments of crew preparedness for early EVAs. The final presentation will describe countermeasures related to spatial disorientation and motion sickness to enable successful crew recovery following return to Earth. Each presentation will include lessons learned from Apollo that can be applied as we develop new strategies for success across the various Artemis mission phases.*

[84] CHARACTERIZING THE RISK: REVIEW OF SENSORIMOTOR EVIDENCE AND RESEARCH ROADMAP

Timothy Macaulay[1], Scott Wood[2]
[1]*KBR/NASA, Houston, TX, United States;* [2]*NASA, Houston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: NASA's Artemis program will take astronauts back to the lunar surface for the first time in almost 50 years. Despite the successes of the previous Apollo program, the Artemis missions will differ in duration, vehicle characteristics, and landing tasks that may exacerbate the risks to crew health/safety and mission objectives. NASA's Human Research Program identifies the risk of altered sensorimotor/vestibular function impacting critical mission tasks as one of the top priority risks to lunar exploration missions. This session will review the existing evidence and remaining gaps in knowledge for the sensorimotor risk. **OVERVIEW:** Alterations in sensorimotor processing during spaceflight can lead to motion sickness, spatial disorientation, and decrements in postural control, locomotion, and fine motor control during and following gravity-transitions. The risk of impairment is greatest during and soon after gravity-transitions, when performance

decrements may have high operational impacts (e.g., manual landings, immediate egress following landing, and early extravehicular activities (EVAs)). Recent studies have specifically improved the risk characterization of changes in perception, motion sickness, postural and locomotor control, manual control, and fine-motor coordination. However, given the difficulty in obtaining measurements during and soon after gravity-transitions, evidence for initial decrements immediately following gravity-transitions remains limited. The most significant gaps in the risk include manual control ability around gravity-transitions, the ability to perform egress/EVAs soon after gravity-transition, and motion sickness during return to Earth. To address these gaps, current research roadmaps leverage both spaceflight studies and ground-based analogs for risk characterization and countermeasure development/validation. **DISCUSSION:** This panel will further describe the current sensorimotor research strategies with an emphasis on the operational scenarios of manual control, EVA, and crew egress. The goal of this research is to accommodate the needs of the crew and facilitate human capabilities to ensure lunar mission success. This work will prepare NASA for successful Artemis missions and enable the next giant leap, the exploration of Mars.

Learning Objectives

1. The audience will learn about the research evidence informing the risk of altered sensorimotor/vestibular function impacting critical mission tasks during lunar exploration missions.
2. The audience will understand how altered sensorimotor/vestibular function impacts the specific operational scenarios of manual vehicle control, extravehicular activities, and crew egress.

[85] THE PREPARATION: GROUND-BASED G-TRANSITION ANALOG FOR TRAINING AND RESEARCH

Eric Groen
TNO, Soesterberg, Netherlands

(Education - Program/Process Review)

BACKGROUND: During spaceflight astronauts undergo transitions between different gravity (G-) environments, e.g., the transition from 1g on Earth to 0g upon entry into weightlessness, or, vice versa, from 0g to 1g upon landing. It is known that such G-transitions may cause space motion sickness, spatial disorientation and postural imbalance: symptoms which are collectively designated 'Space Adaptation Syndrome' (SAS). We have previously shown that SAS can be simulated on Earth by means of prolonged exposure to hyper-gravity in a human centrifuge. This centrifuge paradigm may be a valuable testbed and training tool in preparing astronauts for G-transitions experienced during Artemis missions. **OVERVIEW:** In that previous research program we found that astronauts experience SAS-like symptoms after being exposed to a one-hour G-stimulus of 3g in a human centrifuge. The astronauts' individual susceptibility to this so-called "Sickness Induced by Centrifugation" (SIC) strongly correlated with their susceptibility to SAS in flight. In both cases, symptoms are aggravated by head movements, which trigger nausea, postural imbalance and illusory motion of the visual surroundings. This suggests a disturbance of the central processing of vestibular signals. To test this hypothesis we performed a series of vestibular tests before and after the centrifuge run, showing significant changes in orientation responses which depend on the sense of gravity. For example, the internal reference frame of reflexive eye movements showed reduced sensitivity to head tilt. Also, susceptible subjects showed an increased asymmetry between the otolith organs in the left and right inner ear, supporting a well-known theory on space motion sickness. **DISCUSSION:** Altogether the results indicate that the transition between 3g and 1g causes vestibular re-adaptation problems which are similar to the problems induced by G-transition during spaceflight. The centrifuge paradigm may thus be an adequate way to simulate G-transitions during Artemis missions, and can also be used as training tool that allows astronauts to experience their own response to G-transitions.

Learning Objectives

1. The audience will learn about vestibular problems associated with G-transitions during space missions.
2. The audience will understand how a centrifuge capability can be used as testbed and as training tool to prepare astronauts for Artemis missions.

[86] SAFE ARRIVAL: ISS RESEARCH FOR CHARACTERIZING RISK OF MANUAL CREW OVERRIDE DURING LUNAR LANDING

Kevin Duda
Draper Laboratory, Cambridge, MA, United States

(Education - Program/Process Review)

BACKGROUND: Alterations in vestibular sensory processing due to adaptation to a microgravity environment can lead to motion sickness, spatial disorientation, and sensorimotor impairment upon return to a gravitational environment that may impact manual control proficiency. As NASA prepares to send astronauts back to the moon as part of the Artemis Program, with a potential stop at the cis-lunar Gateway, astronauts may spend several weeks in microgravity prior to descending to the lunar surface. Addressing the risk associated with sensorimotor performance, and manual control of a piloted spacecraft, following long-duration exposure to microgravity is necessary for improving the safety and likelihood of successful lunar landings in NASA's Human Landing System (HLS). **DESCRIPTION:** NASA's Human Research Program (HRP) has funded a research study to quantify the effects of microgravity on simulated lunar landing manual control performance immediately following return to the gravitational environment of Earth, as well as the effect of "just-in-time" training while onboard the International Space Station (ISS). **DISCUSSION:** This presentation will describe how research conducted during ISS missions will be used to explore on-board training as a potential countermeasure for manual control of lunar landings.

Learning Objectives

1. The audience will learn about developing a high fidelity lunar landing simulation for test and evaluation.
2. The audience will learn about performance metrics and techniques for quantifying piloting performance during simulated lunar landing.

[87] SAFE EXPLORATION: SENSORIMOTOR ASSESSMENTS FOR EARLY EXTRAVEHICULAR ACTIVITIES

Sarah Moudy
NASA JSC, Aegis Aerospace, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: Artemis missions will require a new level of crew autonomy around periods of gravitational transition, where sensorimotor disturbances are at their highest. There is a need to define performance thresholds for key sensorimotor assessments that indicate when performance in early extravehicular activities (EVAs) might be impacted or unsafe. This panel presentation will discuss the development of sensorimotor assessments for determining crew preparedness of early EVAs by utilizing a novel portable sensorimotor disorientation analog and other spaceflight analogs. **OVERVIEW:** The assessment tasks were defined based on lessons learned from Apollo and subject matter experts (e.g., flight surgeons) to include the following: 1) mimic body maneuvers such as reaching, bending over, etc. such that crew can self-assess their potential ability to complete operational tasks; 2) provide opportunities to develop strategies to recover from off-nominal body positions; and 3) aid in progressive adaptation to the novel gravitational environment. To define performance thresholds, we proposed to validate this set of sensorimotor assessment tasks under various spaceflight analogs. A Sensorimotor Disorientation Analog (SDA) was developed that could induce varying levels of disorientation through combined vestibular and

proprioceptive disruptions. The SDA was first pilot tested using subjective feedback from previously flown astronauts to determine the levels of disorientation that mimic motor performance immediately and +24hours postflight. A second study was performed using healthy non-astronaut ground subjects to validate the SDA levels by comparing to astronaut postflight data. The validated SDA was utilized in a third study to map performance in the proposed set of sensorimotor assessment tasks to performance on operationally relevant tasks such as capsule egress. This presentation will conclude with a discussion on future validation studies of the proposed assessment tasks using other spaceflight analogs such as centrifugation and gravity offload systems. **DISCUSSION:** Exploration class missions will require crew to be able to self-assess and treat their sensorimotor dysfunction after gravity transitions, and in off-nominal situations they may be required to perform provocative, challenging tasks soon after landing. This panel presentation will discuss current and ongoing research strategies to address the sensorimotor risk on safe exploration during Artemis missions.

Learning Objectives

1. The audience will understand the sensorimotor risk for early extravehicular activities.
2. The audience will learn about a proposed set of sensorimotor assessment tasks for crew self-assessment of abilities to perform operational tasks during missions.

[88] SAFE RETURN: MITIGATING MOTION SICKNESS FOR EARTH RE-ENTRY AND CREW EGRESS

Taylor Lonner, Aaron Allred, Aadhit Gopinath, Tori Mogheim, David Temple, Torin Clark
University of Colorado-Boulder, Boulder, CO, United States

(Education - Program/Process Review)

BACKGROUND: Following sustained exposure to microgravity, astronauts have an altered interpretation of sensory cues, particularly those from the vestibular system, which is maladaptive for re-entering Earth's gravity. This typically leads to motion sickness and sensorimotor impairment, which can negatively impact operational tasks such as crew egress. During water landings on Earth, such as planned during Artemis, the sea state passive motion with restricted views of external visual references prior to recovery can exacerbate motion sickness. Fundamentally, motion sickness is thought to be produced due to sustained "sensory conflict" or differences between sensory afferent measurements and the brain's expectation of sensory measurements. Means of reducing sensory conflict by helping the brain more accurately produce expectations of sensory measurements are likely to mitigate astronaut motion sickness during re-entry. **OVERVIEW:** Here, we present evidence supporting potential countermeasures for mitigating motion sickness and sensorimotor impairment relevant for Earth re-entry. We simulated the gravity transition associated with Earth re-entry using sustained Gx centrifugation followed by passive motions mimicking sea state motion. As compared to a control condition with a fixation point, we found providing a rich scene of motion-congruent, Earth-fixed visual cues in virtual reality significantly reduced the proportion of subjects who reached sustained "moderate" motion sickness (21% vs. 67%). In addition, we have tested how providing anticipatory cues of upcoming motion could help reduce motion sickness. Further, we explored two uses of galvanic vestibular stimulation (GVS). First, by using a novel computational model to quantify how the brain processes simultaneous vestibular stimulation from physical motion and GVS current, we aimed to reduce vestibular sensory conflict. Second, to improve vestibular sensory information transfer, we assessed using noisy galvanic vestibular stimulation (nGVS) to produce stochastic resonance. We found that applying nGVS improved translational vestibular perceptual thresholds (how small of a motion can be reliably sensed) by 28+/-9%. **DISCUSSION:** Mitigating motion sickness that is expected during Earth re-entry is critical to ensure astronaut well-being and adequate performance. Approaches which aim to reduce sensory conflict provide an avenue to reduce motion sickness and operational risks during crew egress.

Learning Objectives

1. Understand the concept of "sensory conflict" and how it leads to motion sickness.
2. Understand how visual and vestibular manipulations can be used to reduce motion sickness.

Monday, 05/06/2024 ***4:00 PM***
Grand Ballroom A

[S-18]: PANEL: PILOT-PHYSICIANS; A HISTORY OF PERFORMANCE, ENDEAVORS FOR THE FUTURE

Chair: Thomas Powell
Co-Chair: Sandra Salzman

PANEL OVERVIEW: *BACKGROUND: As mankind began to take flight through various ways, medical and physiological challenges had to be overcome to accomplish the flight safely and effectively. Ever since Dr. John Jefferies piloted the first hot air balloon across the English Channel in the 1700's, individuals with both aviation and medical expertise have been instrumental in overcoming the physiological and human factors challenges presented by the aerospace environment. Now known by the moniker "Pilot-Physicians", these dual-qualified individuals represent a small but eager community who continue to help solve modern aerospace medicine issues. OVERVIEW: Here we describe the various projects, proposals, and lessons learned by Pilot-Physicians. These presentations describe new problems, solutions, techniques, and procedures that individual Pilot-Physicians are involved with and helping their respective aviation communities to overcome. DISCUSSION: The various talks contained within this panel cover a spectrum of topics which range from operational to clinical to the areas in-between. As aircraft and their missions increase in complexity, these discussions will explain how these challenges are being overcome and the way forward for future endeavors. Many of these aerospace issues are cross-service as the Pilot-Physician community labors to improve human performance within the aerospace environment.*

[89] STABILITY OF VISION AT ALTITUDE AFTER SMILE CORNEAL REFRACTIVE SURGERY

Carter Tisdale[1], Timothy Soeken[2]
[1]*U.S. Air Force, San Antonio Uniformed Services Health Education Consortium, San Antonio, TX, United States;* [2]*U.S. Air Force, Wilford Hall Ambulatory Surgical Center, San Antonio, TX, United States*

(Original Research)

INTRODUCTION: Corneal refractive surgery (CRS) has revolutionized human visual performance in a variety of professional fields, environments, and activities by taking away the patient's need for spectacle correction to see well. Photorefractive keratectomy (PRK) and laser-assisted in situ keratomileusis (LASIK), the mainstay CRS procedures for triservice military personnel over the past one to two decades, have optimized the military's deployment capabilities and operability in austere suboptimal environments. Small incision lenticule extraction (SMILE) is the newest CRS procedure to have been approved for military personnel and aviators. Many studies and case reports were published in the 1990's and early 2000's about the visual instability of radial keratotomy (RK)–the oldest CRS procedure–at high altitude conditions. These findings led to high altitude studies of PRK and LASIK patients, all of which demonstrated stable vision at various altitudes. In our study, we sought to prove the vision and corneal stability of SMILE patients

in a hypobaric environment. **METHODS:** This was a non-randomized, unmasked, prospective study of 20 active-duty military volunteers who had undergone SMILE refractive surgery for correction of near-sightedness at least 1 month prior. High- and low-contrast visual acuity, automated refraction, corneal thickness, and corneal topography were each measured at ground level and at 10,000, 15,000, 18,000, and 22,500 ft simulated altitudes in a hypobaric chamber. Subjects were permitted to utilize artificial tear lubrication throughout the chamber flight. A portable slit lamp device was used to assess the cornea's appearance at ground level and at 22,500 ft simulated altitude in all subjects. Statistical significance of the comparison between the measured variables at ground level and at the respective altitudes was assessed using the ANOVA analysis tool. **RESULTS:** In the 20 study eyes tested there were no statistically significant changes in high- or low-contrast visual acuity, refraction, average corneal power, or corneal thickness among the subjects. **DISCUSSION:** Our study suggests that visual performance remains stable at altitudes up to 22,500 feet in patients who have undergone SMILE refractive surgery. This is especially applicable to military aviators who routinely perform their duties at altitude. Time at altitude was limited, so future research may include prolonged exposure at 22,500 ft or higher.

Learning Objectives

1. The audience will learn about the history of corneal refractive surgery (CRS) procedures and patients' vision stability in abnormal environments.
2. The participant will be able to understand how the cornea–and ultimately, vision–can physiologically be altered in a hypobaric environment.

[90] NVG HIGH-SPEED, LOW-LEVEL SIMULATION FLIGHT IN A TILT-ROTOR MODEL

Ian Curry[1], Steve Gaydos[2]
[1]*U.S. Army Aeromedical Research Laboratory, Fort Novosel, AL, United States;* [2]*HQ Army Air Corps, Middle Wallop, United Kingdom*

(Original Research)

INTRODUCTION: The Future Long Range Assault Aircraft platform leverages tilt-rotor (TR) technology possessing significant advances in speed, maneuverability, and range. The expanded performance envelope and capabilities of these aircraft demand careful attention to the human operator including capacity, performance, communication, workload, fatigue, and safety. Future challenging environments within large-scale combat operations will drive maneuvering altitudes lower to include contour and low-level tactics. **METHODS:** A test was conducted in the vertical motion simulator at Ames Research Center, California to assess the ability of Army pilots to conduct high speed (HS), low-level (LL) and contour flight (CF) using a TR aircraft model. Six pilots conducted more than 300 test runs over flat, rolling, and mountainous terrain at airspeeds from 120-220 knots in both day and night vision goggle (NVG) conditions. Performance was judged by two primary metrics: Time spent above the doctrinally established threshold altitude as a percentage of total time for a test run and number of ground/obstacle strikes during each run. **DISCUSSION:** Within the limited scope of this test effort, it was determined that HS (up to 220 knots), LL flight was possible in all terrain types under both day and NVG conditions. HS CF was possible in flat terrain; however, HS CF in rolling or mountainous terrain was not possible without significant risk of ground/obstacle contact or significant time spent above contour altitude. In all cases, optimal NVG conditions (full moon illumination) produced essentially the same results as day conditions.

Learning Objectives

1. Participants will broadly recognize operational advantages and disadvantages of tilt-rotor aircraft.
2. Participants will appreciate maneuvering challenges associated with low-level and contour flight under various operational conditions.

[91] SILVER LINING STUDY: MISSILEER FATIGUE MITIGATION DURING 2020 CORONAVIRUS PANDEMIC

Sandra Salzman[1], Ashley Wiser[2], Jackson Prestwood[3], Tyler Wagner[4], Megan Morris[5]
[1]*86th Air Wing, Ramstein AB, Germany;* [2]*U.S. Air Force, Arlington, VA, United States;* [3]*U.S. Air Force, San Antonio Military Medical Center, Fort Sam Houston, TX, United States;* [4]*U.S. Navy Naval Medical Center Portsmouth, Portsmouth, VA, United States;* [5]*U.S. Air Force Material Command, Wright-Patterson AFB, OH, United States*

(Original Research)

INTRODUCTION: Since inception, ICBM Missileers operate consoles on 3-day cycles:min 24-hr alert-shift/24-hr travel/24-hr off-admin, leading to concerns that health, morale, and alertness are chronically impacted. 2020 Missileer Occupational Health Assessment (OHA) revealed 76% of missileers "struggle with being rested for duty" and 29% "never feel adequately rested for duty". The COVID pandemic increased operations tempo and crew fatigue. Scheduling of underground ICBM crews has similarities to space-based duty cycles. **METHODS:** All participants, Nuclear Missile Operations Officers, were continuously evaluated qualitatively and quantitatively to ensure nuclear safety. Interventions implemented and evaluated during the 9-mo period included: environmental modifications, scheduling changes, and crew education on fatigue management, nutrition, sleep hygiene, and fitness. 341st OG examined various 3-person and 4-person shift-length and alert duration schedules first in SAFTE-FAST scheduling software and if safe, on the mission console. Psychomotor Vigilance Testing (PVT) results validated crew safety and delta between pre- and post-shift measurements. AHLTA trends were analyzed for force-health awareness. Pre- and post-study OHA results were compared. Fatigue and health-related outcomes were collected from safety monitoring efforts during standard and COVID-19 operations at 341st Missile Wing. **RESULTS:** Max safe alert-duration is 7-days due to task fatigue onset between 8-10 days. Optimal schedule is a 3-week cycle:7-day alert/7-day recovery/7-day training-admin. PVT suggested traditional 4-member and new 3-member crew shifts are safe. On this schedule, short and long-duration Duties Not to Include Flight rates decreased by 74.6% and 79.2% respectively. Alerts/month missed decreased 86% from baseline. Anxiety and chronic pain visits fell by 57% and 18% respectively. 2021 Missileer OHA found a 7% decline in members seeking separation, and a complete absence of sleep, fatigue, and physical or mental health complaints. **DISCUSSION:** Implementation of reliable schedules emphasizing protected recovery and training time were associated with significant improvements in health and retention, compared to baseline. Trialing crew ideas, with medical support and analysis, improved trust of missileers, work-life balance, schedule stability, unit cohesion, and retention. Global Strike Missile Operations Groups adjusted scheduling practices to align with these findings.

Learning Objectives

1. Consider the value of recovery time in human factor analysis to mitigate fatigue, chronic complaints resulting from shift work disorder, and lack of work-life balance that may impact retention factors.
2. Understand climate factors in proposing and implementing change in risk averse organizations.
3. Military flight medicine involves evaluating airman that operate in non-standard conditions, including subterranean, air, and space. A deep understanding of the occupational requirements both on and off duty, can help providers give impactful, data driven recommendations to patients and commanders.

[92] CASE REPORT: TREATMENT WITH TRANSCRANIAL MAGNETIC STIMULATION IN A PILOT WITH LONG-COVID SYMPTOMS AND POSTURAL ORTHOSTATIC TACHYCARDIA SYNDROME

Benjy Park[1], Joe Zhang[2]
[1]*Joint Base Langley-Eustis, Hampton, VA, United States;* [2]*Edwards AFB, CA, United States*

(Original Research)

INTRODUCTION: The association between long COVID and Postural Orthostatic Tachycardia Syndrome (POTS) is increasingly recognized in the medical literature. Less defined is the association between POTS and COVID-19 vaccination. Transcranial magnetic stimulation (TMS) treatment strategies have been observed beneficial to alleviate some of the concerns related to long COVID, however there is a paucity of data to demonstrate any viability in treatment of POTS and more specifically, in long COVID related POTS. We describe a case that attempted to use TMS on such a patient. **METHODS:** A 32-year-old USAF pilot was suffering from symptoms of cognitive difficulties such as "brain fog" and orthostatic tachycardia for two years following COVID-19 vaccination and infection. He was evaluated with a battery of high-performance athletic training cognitive tests, then treated with 10 sessions of Electro-Magnetic Brain Pulse (EMBP®) which is a personalized TMS protocol guided by the patient's Electro Encephalograph (EEG). In addition, he also received rounds of peripheral magnetic nerve stimulation over the Vagus nerve. **RESULTS:** After treatment series, the high-performance athletic training cognitive tests demonstrated a 15% overall increase in his total score. The patient reported that his symptoms of "brain fogging" was subjectively improved by 50%. Post treatment EEG also showed an improved synchronized alpha wave pattern during the resting state. Unfortunately, the POTS symptoms did not respond to any of the treatments. **DISCUSSION:** Brain stimulation techniques appear to show early signs of success with long COVID cognitive symptoms. This is the first case describing use of TMS and peripheral magnetic nerve stimulation in an attempt to treat COVID related POTS. While some cognitive symptoms showed subjective improvement, tachycardia symptoms did not seem to respond and warrants further research. The human performance and cognitive measures may be especially important for combat aviators who have a much higher cognitive demand than the normal population.

Learning Objectives

1. Gain an understanding of the challenges quantifying Long COVID.
2. Gain an understanding of new developments in treating Long COVID.
3. Gain an understanding of new performance techniques to measure human performance.

[93] AIR FORCE SPECIAL OPERATIONS COMMAND SPECIAL OPERATIONS FLIGHT MEDICAL ELEMENT REORGANIZATION

Christopher Backus
Air Force Special Operations Command, Hurlburt Field, FL, United States

(Education - Program/Process Review)

BACKGROUND: Some United States Air Force (USAF) Flight Surgeons (FS) operated in teams called Squadron Medical Elements (SMEs), assigned to flying squadrons and commanded by aviators. Specially trained SMEs in Air Force Special Operations Command (AFSOC) were Special Operations Flight Medical Elements (SOFMEs). Since 2001, AFSOC adapted to counter terrorism. Afghanistan was a significant area of responsibility and withdrawal led to reevaluation of the resulting organization, within a setting of change throughout the US Military Health System (MHS) as the Defense Health Agency (DHA) centralized control and the USAF reorganized to support operational medicine. **OVERVIEW:** Prior to the withdrawal, SOFMEs were centralized in a Special Operations Support Squadron (SOSS). The senior FS scheduled training and deployments. A pool of SOFME flight surgeons rotated duties, shared information, and trained together. However, SOFMEs were not connected with a flying squadron nor commanded by individual squadron commanders, but by a SOSS commander. After withdrawal, command of SOFMEs was decentralized with one in each flying squadron. This allowed the SOFME to focus on the unique aeromedical challenges of each airframe and mission. However, decentralization created challenges with scheduling of training and deployments. Decentralization threatened the role of the senior SOFME FS. Meanwhile, centralization of control with the DHA threatened to disrupt the connection between the Wing Commander and the MTF Commander. This connection was traditionally a strength. So, an ideal solution to the problems of decentralizing SOFME flight surgeons would strengthen the connection between the Wing Commander and the MTF Commander. To address challenges, medical leaders created a new job, Special Operations Wing Surgeon (SOW/SG). Discussion of whether to appoint the MTF Commander as SOW/SG and task the senior FS as deputy or the reverse was pending, but the solution was designed to get benefits from decentralization while retaining benefits of centralized physician oversight, all while strengthening connection between Wing and MTF. **DISCUSSION:** Centralized vs decentralized control is a consistent theme and this case demonstrated one approach to gaining benefits of each while illustrating the unique organization of AFSOC flight medicine. Balance between line command and medical oversight was another common issue in military medicine demonstrated by this program review.

Learning Objectives

1. The participant will gain an overview of the USAF SME structure and the specialized AFSOC SOFME organization.
2. The audience will understand advantages and disadvantages to centralization vs decentralization of AFSOC SOFME teams.

Monday, 05/06/2024 ***4:00 PM***
Grand Ballroom B

[S-19]: PANEL: UPDATING ATTENTION-DEFICIT/ HYPERACTIVITY DISORDER MEDICAL CERTIFICATION POLICY

Chair: Randy Georgemiller

PANEL OVERVIEW: *Attention-Deficit/Hyperactivity Disorder (ADHD) is a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development. The nature of the neurocognitive and behavioral symptoms associated with ADHD are medically disqualifying and pose a significant aviation safety risk. Aviation fatalities have been associated with the condition (Laukkala, et al., 2017). Multiple factors have increased the burden for the FAA in making medical certification decisions for ADHD to include historically cursory diagnostic workups for the condition (Bruchmuller, et al., 2012), the surging number of cases in our society potentially tied to drug seeking for performance enhancement in occupational and academic settings, and the labor intensity of the review itself for FAA Medical Review Officers and specialists. Internal data also confirms the rise in the number of case reviews at the FAA. The FAA policy for ADHD entailed extensive neuropsychological evaluation for at least the last 10 years. A recent review of the literature related to ADHD, canvassing aviation medical policy from non-FAA agencies, and consultation with internal and external medical, behavioral health, and neurological professionals led to an updated ADHD policy consisting of dual tracks for those diagnosed with ADHD for which record review and interview would suffice in specified cases compared to those requiring neuropsychological assessment. The streamlined protocol was associated with delineating those ADHD applicants posing a lower versus higher aviation safety risk and apply an appropriate level of assessment and review. Details of the FAA ADHD Fast Track/Standard Track will be reviewed along with a Fast Track case example which does not require the administration of standardized neuropsychological measures.*

[94] UNDERSTANDING FAA ADHD POLICY CHANGES

Judith Frazier
FAA, Washington, DC, United States

(Education - Program/Process Review)

BACKGROUND: Policy changes in ADHD reflect knowledge, experience, disease pathology or change in standards of care. This presentation will inform aerospace medicine personnel on the history of ADHD policy changes and documentation tools for the new ADHD pathway. **OVERVIEW:** The ADHD working group identified what information was needed to evaluate a pilot/ATCS who reports ADHD or use of ADHD medication. The condition was stratified into risk "rows of severity". This approach identified subset of pilots/ATCS unlikely to be of aeromedical risk and may not require testing. The community provider is guided to answer specific questions related to safety and the AME or FAA review to make the certification decision. Policy documents were created to help external providers understand what the FAA requires. The tools also streamline the workflow within the FAA by putting the relevant questions in the same place and instructing the provider how we need the information displayed to make a certification/clearance decision. The policy progression is a result of expertise in the subject coupled with creation of tools useful for case processing. **DISCUSSION:** ADHD is a high-volume condition for the FAA. It is identified in students who have been on medication since childhood and adults taking medication as a performance enhancer. It appeared in the AME Guide in 2004 (listed as Attention Deficit Disorder) and required FAA Decision. The original ADHD/ADD Protocol (published in March, 2013) required a full neuropsychological battery on all pilots with ADHD. This protocol was revised in 2018 to allow for a shortened "core" test battery and supplemental battery when indicated. In either case, extensive review was required by AAM and testing was required by almost all applicants. The recent policy changes streamline the evaluation process to advance aerospace medicine by accurately testing those who need testing, not requiring testing from those who do not, and standardizing the way cases are reviewed for consistency.

Learning Objectives

1. The audience will be able to identify the changes made to the ADHD policy.
2. The audience will earn how the FAA uses the FAS TRACK FAA ADHD summary to review cases.
3. The audience will be able to identify the current AME actions.

[95] EXPANDED PATHWAYS FOR CLEARING ADHD CASES

Joyce Fowler
Fielding Graduate Institute (now University), Santa Barbara, CA, United States

(Education - Tutorial/Review)

INTRODUCTION: ADHD is a disqualifying diagnosis. The FAA ADHD workgroup, in consultation with external experts in the field, developed new AME Guidelines providing clearer guidance and expanded the pathways for ADHD evaluations. Informed by updated practices, the guidelines: leverage skill sets, improves review time, reduce cost & time for some applicants, adapts to the increasing number of cases, and expands the pool of initial evaluators. **TOPIC:** This presentation will delineate the two updated FAA ADHD Pathways and referral patterns for expedited processing. The Fast Track pathway assesses for the presence or absence of ADHD. The ADHD Standard Track meets FAA ADHD specifications for neuropsychological evaluation for more complex cases. **APPLICATION:** The new Fast Track pathway with an expanded pool of initial evaluators and virtual interview options saves time, money, and resources for a select group of airmen. Established criteria for airmen without symptoms, medication usage, other comorbid psychiatric conditions, and stable functioning allows for a more streamlined approach to assessment. A comprehensive airmen checklist provides explicit guidance empowering the airman to facilitate expediency. Referral patterns allow for more flexibility and increase access for airmen. A standardized protocol including review of required records and clinical interviews provides the bases for community-based assessments by psychologists and neuropsychologist with expertise in ADHD. Referrals for Standard Track assessments by FAA HIMS trained neuropsychologists for cases that do not meet established Fast Track criteria remains in place. **RESOURCES:** Federal Aviation Administration, Guide for Aviation Medical Examiners https://www.faa.gov/ame_guide/dec_cons/disease_prot/adhd

Learning Objectives

1. The participants will be able to delineate criteria for two pathways for evaluating for ADHD.
2. The participants will understand referral pathways to help expedite case processing.
3. The participants will understand records requirements for processing cases.

[96] INPUT FROM NON-FAA REGULATORY ENTITIES

Forest Pavel
University of Missouri-Kansas City, Kansas City, MO, United States

(Education - Program/Process Review)

EDUCATION: INPUT FROM NON-FAA REGULATORY ENTITIES

BACKGROUND: ADHD is a disqualifying diagnosis, yet it is increasingly diagnosed within the current aviation population, and among those seeking initial certification. The FAA ADHD workgroup, in consultation with external experts in the field, developed new AME Guidelines providing clearer guidance and expanded the pathways for ADHD evaluations. As part of the decision-making process, the FAA ADHD workgroup reviewed guidelines from multiple non-FAA entities, both military and civilian, as part of their decision-making process. **OVERVIEW:** This presentation will examine the differences and similarities between multiple non-FAA regulatory entities. Current aeromedical guidelines from the United States Army (Aeromedical Policy Letters), Navy (Aeromedical Reference and Waiver Guide), Air Force (Aerospace Medicine Waiver Guide/Air Force Waiver Guide), and Australian Civil Aviation Safety Authority (CASA) Clinical Practice Guidelines will be explained. Information regarding how those entities view ADHD from an aerospace safety perspective will be highlighted. Clinical evaluation and waiver processes from those entities will also be reviewed to ascertain how they differ from current FAA guidelines. **DISCUSSION:** When engaging in a regulatory change process, informed decision-making is key when working from an aeromedical safety perspective. As airspace is a shared environment it is important to review, compare, and contrast the policies of those who operate within it. Aviators in both the military and civilian sectors operate within the same National Airspace, yet among four separate regulatory bodies each treat evaluation and decision-making for waiver/special issuance for ADHD differently. The Australian CASA regulations were also reviewed in order to examine how a comparable civilian agency evaluates ADHD amongst its aviator population. Information gleaned factored into the creation of a new standardized FAA protocol which seeks to streamline the process for a select group of airmen who qualify for the ADHD Fast Track pathway.

Learning Objectives

1. The participant will recognize that aviation regulatory agencies apply medical standards differently among their aviators despite sharing the same airspace, leading to individuals being variously medically eligible or ineligible dependent upon which regulatory body they fall under.
2. The participant will be able to understand differing standards for ADHD evaluation within US militaries and Australian Civil Aviation Safety Authority.

[97] ADHD AS A MEDICALLY DISQUALIFYING CONDITION

Randy Georgemiller
FAA, Washington, DC, United States

(Education - Program/Process Review)

BACKGROUND: For more than two decades the FAA has deferred medical certification for the presence of Attention Deficit Disorder now categorized as Attention-Deficit/Hyperactivity Disorder (ADHD). When the presence of the condition is confirmed, it is medically disqualifying. **DESCRIPTION**: ADHD is a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development. A disorder typically diagnosed in childhood, symptoms may persist into adulthood and adversely affect social, academic, and occupational functioning. Associated neuropsychological symptoms impact a broad range of cognitive domains, all of which pose potential risks to aviation safety. While causation cannot be assumed, nonetheless, ADHD associated aviation fatalities have been documented based on case study and analyses of National Transportation and Safety Board (NTSB) data. **DISCUSSION**: Multiple factors associated with ADHD present significant challenges for aviation medical certification decisions. The limited diagnostic workup of many ADHD cases poses a challenge for medical review officers who are tasked with determining the authenticity of the diagnosis based on record review. Given the short-term performance enhancement which can be realized in occupational and academic settings with the use of psychostimulants, the diagnosis has been inappropriately applied to those driven by medication seeking. Medical certification decisions are further complicated by the frequent comorbidity of ADHD with other mental conditions which are potentially disqualifying. Given symptom overlap with other developmental disorders such as Autism Spectrum Disorder and Specific Learning Disorders, determining aviation safety risk is particularly challenging. Chronologically, FAA ADHD-related applications showed an approximately 33% increase over a five-year period and in 2023 the estimated number of cases is just under 2,500. Given the above factors, case review for medical certification is labor intensive relying on the expertise of FAA Medical Review Officers, Neuropsychologists, Psychiatrists, and Neurologists.

Learning Objectives

1. The participant will be able to describe three ADHD symptoms that pose an aviation safety risk.
2. The participant will be able to list ADHD comorbid conditions which are aeromedically disqualifying.
3. The participant will be able to identify factors that limit the ability to accurately identify a history of ADHD.

[98] ADHD DIAGNOSED IN AN ADULT AND RELEVANCE TO THE FAST TRACK PATHWAY

Robert Mapou
Oceanside Neuropsychology, Rehoboth Beach, DE, United States

(Education - Case Study)

INTRODUCTION: This case study illustrates an incorrect adult ADHD diagnosis due to inadequate record review and not considering contributing stressors. **BACKGROUND:** Proper adult ADHD diagnosis requires interviews; a detailed developmental history based on interviews and record review, review of symptom onset and possible contributing factors, and ratings of current symptoms (e.g., Barkley et al., 2008; Mapou, 2023). Until recently, FAA applicants with ADHD required neurocognitive screening, with additional testing for deficits identified on screening. For the Fast Track pathway, an interview and record review may suffice. **CASE PRESENTATION:** A 52-year-old former USAF enlisted officer was diagnosed with ADHD at age 40. However, evaluations by a psychiatric nurse practitioner, a psychologist a psychiatrist, and a PCP relied on self-report only. While the nurse practitioner and psychologist noted stresses related to deployment, anxiety, sleep deprivation, and promotion to a position with more responsibility, ADHD was diagnosed as the cause of the patient's attention problems. He was treated with medication but experienced side effects after being switched from bupropion to psychostimulant medication. He continued treatment as a civilian. Medical records confirmed the cursory evaluations. The psychiatrist had written "No h/o developmental problems." consistent with current self-report. Academic records from several colleges showed strong grades before and during treatment. The patient had advanced quickly before being treated. Performance ratings and commendations showed no problems both before and during treatment. Rating scales completed by the patient and his wife showed a few symptoms of ADHD but not enough to diagnose ADHD. The summary CogScreen score was outside the normal range, due to three Low Average scores and one Below Average score. The profile showed a tradeoff of speed for accuracy. Neuropsychological screening with supplementary measures of mental math and visuospatial skills, however, showed strong skills. Personality testing showed no concerns. **DISCUSSION:** This case, judged appropriate for the Fast Track Pathway, illustrates the importance of never considering self-report alone when diagnosing ADHD, reviewing records that provide objective information, and thoroughly considering other causes of new-onset attention symptoms in an adult.

Learning Objectives

1. Understand how ADHD may be incorrectly diagnosed based on self-report only.
2. Understand how the FAA Fast Track Pathway provides a way to determine medical certification eligbility based on a record review and interview.

Monday, 05/06/2024 ***4:00 PM***
Grand Hall J

[S-20]: SLIDES: RETURNING TO FLIGHT DUTY

Chair: Tarek Sardana
Co-Chair: Denise Baisden

[99] RETURN TO OPERATIONAL SEARCH AND RESCUE DUTIES POST TOTAL HIP ARTHROPLASTY

Maj Melissa Gear[1], Col Max Talbot[2]
[1]*Canadian Armed Forces, Winnipeg, MB, Canada;* [2]*Canadian Armed Forces, Montreal, QC, Canada*

(Education - Case Study)

INTRODUCTION: This case report describes a military Search and Rescue Technician (SAR Tech) who required a total hip arthroplasty (THA) and the following risk assessment to allow return to operational duties. **BACKGROUND:** Royal Canadian Air Force aircrew occasionally return to aircrew duties following a total hip arthroplasty, but a structured approach to evaluate the operational risk of post-procedure periprosthetic fractures and hip dislocations has not been well established. Newly available nomograms, which can provide individualized 5-year risk forecasts, combined with aeromedical risk matrices provide a better starting point to evaluate individual aircrew risk. SAR Techs are a subset of aircrew who are required to preform a variety of demanding physical tasks which requires a detailed assessment of risk for return to operational activities. **CASE PRESENTATION:** The subject was a > 40-year-old experienced Royal Canadian Air Force Search and Rescue Technician with > 2200 total flying hours over multiple platforms, and 88 total dive hours who suffered hip injury from a fall from height in 2016. Despite rapid development of post-traumatic arthritis, they managed to continue operational SAR duties with conservative treatment until their function had deteriorated with increase pain and frequent locking episodes in 2018. After excellent response to corticosteroid injection, they had a brief return to operations until an eventual THA (uncemented porcelain on polyethylene via posterolateral approach) in 2020. After 18 months of rehab and excellent recovery, the member was cleared to gradually return to training duties which were well tolerated. Two full

years post procedure, the SAR Tech was cleared to return to operational duties with the exception of operational parachuting. **DISCUSSION:** It is not advised to return to full military aircrew duties in the year following a THA as this period has the highest rate of complications, and aircrew are required to rehabilitate back to a level of fitness required for operational standards. Combining nomograms with aeromedical risk matrices provides solid assessment foundation, but this case highlights the limitations in deducing operational risk in complex cases or operational environments.

Learning Objectives

1. The audience will understand ways to combine available clinical nomograms with aeromedical risk matrices to more precisely determine operational risk in return to duty after joint arthroplasty.
2. The audience will explore the limitations in application of calculated risk assessments to complex aircrew tasks or environments.

[100] FROM GROUND TO CLOUD: STREAMLINING AEROMEDICAL EVALUATIONS WITH CLINICAL DECISION SUPPORT INNOVATIONS

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

(Education - Program/Process Review)

BACKGROUND: Flight physicals are essential to ensure the health and safety of pilots and crew, providing a comprehensive evaluation of an individual's fitness to fly. With the rapid advancements in medical technology and the increasing complexity of aerospace medicine, there is a growing need for a standardized, evidence-based approach to conducting flight physicals and analyzing the population data they contain. AsMA attendees will benefit from understanding the importance of implementing clinical decision support (CDS) systems in this context, especially as the demand for streamlined and accurate flight physical evaluations continues to rise. **OVERVIEW:** Clinical decision support systems offer a robust solution to enhance the quality and consistency of flight physicals. Implementing CDS tools for flight physical evaluations involves integrating electronic health records with real-time, evidence-based guidelines and recommendations specific to aerospace medicine. This presentation will discuss the development of a CDS framework tailored for flight physicals, detailing its design, functionalities, and the challenges faced during its implementation. The system's primary aim is to assist medical professionals in making informed decisions by providing them with relevant data, predictive analytics, and best practice guidelines during the evaluation process. **DISCUSSION:** Understanding the current state of electronic health record technology allows accurate and complete gap assessments. Implementing CDS can revolutionize the approach of aerospace medical professionals. By providing consistent and up-to-date information, system implementation ensures that evaluations are thorough, accurate, and aligned with the latest medical research. The integration of CDS not only streamlines the process but also elevates the standard of care in aeromedicine. By relying on evidence-based recommendations, medical professionals can make better-informed decisions directly impacting human performance. A unified CDS framework for flight physicals leverages medical ontology for versatile and adaptable implementation across various international, military, and civilian sectors. Its universal design promotes collaboration and knowledge sharing, fostering a more unified approach to aerospace medicine worldwide. Further, CDS implementation facilitates a structured approach to data analysis, adjusting medical practice to provide a balanced risk approach.

Learning Objectives

1. Recognize the significance of standardized, evidence-based flight physicals and the role of clinical decision support (CDS) systems in enhancing the quality and consistency of evaluations in aerospace medicine.
2. Appreciate the potential of a unified CDS framework in promoting collaboration, knowledge-sharing, and a balanced risk approach in aeromedicine across international, military, and civilian sectors.

[101] REVISITING MIGRAINE

Sarita Dara, Claude Preitner, Sprott Tim
Civil Aviation Authority of New Zealand, Wellington, New Zealand

(Education - Program/Process Review)

BACKGROUND: Migraine is a common medical condition in applicants for initial pilot medical certification. In view of the unpredictability of its occurrence and potential for incapacitation, it is assessed as a condition of aeromedical significance. Civil Aviation Authority New Zealand (CAA NZ) medical standards have considered the various factors such as nature of migraine and aura, medications use as well as recurrence free interval for certification of initial class 1 and 2 applicants. However, it is noted that policy from other regulators such as US Federal Aviaiton Authority (FAA) and Civil Aviaiton Authority United Kingdom (CAA UK) show a variation in the approach and variable recurrence free interval for migraine prior to certification. **OVERVIEW:** A literature review was undertaken to review the current evidence base, aeromedical certification approach and consideration for cases of headaches and migraine in various countries. Also, a review of cases of headache and migraine in the CAA NZ medical database over a two-year period of time was undertaken. Only cases processed through the flexibility pathway at the central medical unit were included in the final analysis. Certification approach and considerations were compared and analyzed. Analysis of NZ CAA certification data helped to understand the considerations for certification in the local context and enabled a review of the migraine free observation period for certification. An algorithm for assessment of headache is proposed for aeromedical certification of applicants with migraine/migraine like conditions. **DISCUSSION:** A history of headaches that is diagnosed as migraine either by treating general practitioner or by specialist physician is relevant for pilot applicants, in view of the potential implications for flight safety. Migraine assessment involves a multidimensional review of the various symptoms, signs as well as treatment. The proposed algorithm includes the relevant factors that will aid aeromedical decision making for both Medical Examiners and Regulators.

Learning Objectives

1. Learn about Migraine and comparative analysis of aeromedical standards in different countries for headaches/migraine.
2. Learn about the factors influencing certification decision for migraine in CAA NZ.

[102] CHOROIDAL OSTEOMA IN A COMMERCIAL AVIATION PILOT: CASE REPORT

Daniela Castro Quiroga[1], Miguel Fernando Caro Sepulveda[1], Armando Rafael Martinez Medrano[1], Alexandra Mejía Delgado[2], Johana Giraldo Alzate[2], Diego García Morales[1]
[1]*Universidad Nacional de Colombia, Bogota, Colombia;* [2]*Colombian Civil Aviation Authority, Bogota, Colombia*

(Education - Case Study)

INTRODUCTION: This case describes the pathway of an active commercial airline pilot to get a special issuance, due to a progressive visual field deterioration in his left eye caused by a choroidal osteoma. **BACKGROUND:** Choroidal osteoma (CO) is a benign tumor of the choroid with calcifying characteristics, caused by thinning of the retinal pigment epithelium. It produces progressive deterioration in the visual acuity, leading to monocularity. Although monocularity could compromise the capacity of the pilot to maneuver an aircraft as stereopsis and a portion of the visual field are lost, there are monocular cues and other operational techniques that can be learned to enhance depthness perception and visual scanning to ensure safe operations.**CASE PRESENTATION:** This is a 48 years old pilot, with dyslipidemia treated with atorvastatin, bladder biopsy negative for malignancy and family history of acute myocardial infarction and dyslipidemia. He flies an Airbus A320 and has 25 years of experience. Since 2016, he has been facing gradual deterioration in his left eye visual field. CO was diagnosed via ocular ultrasound. Later, in 2018, choroidal neovascularization was detected with an optical coherence tomography,

which has been treated with intravitreal anti-vascular agents (30 doses so far). He continued his duty as a pilot until 2022 when his medical certification was postponed to be evaluated by the Colombian Aviation Authority (CAA) due to low vision and central field alteration. **DISCUSSION:** CO causes progressive reduction in visual acuity and field, but a special issuance is possible with certain restrictions. The visual system gives up to 80% of the flight-related information. Stereopsis is the primary binocular cue, so monocular pilots need a minimum of 6 months of training to perform safe flight operations. Also, visual acuity and remaining visual field of the unaffected eye are important for aeromedical decision-making, which should be accompanied by performance evaluations such as a medical flight test. To our knowledge this is the first report of a commercial aviation pilot with CO receiving a special issuance. We provide a comprehensive performance-based approach informed by clinical assessment of a pilot with monocular low vision toward aeromedical certification.

Learning Objectives

1. The audience will learn what the CAA considered regarding clinical conditions and operational experience in a case of a pilot with choroidal osteoma with gradual vision loss and his return to flight duties.
2. Provide a comprehensive performance-based approach informed by clinical assessment of a pilot with monocular low vision toward aeromedical certification.
3. The audience will learn how a medical flight test was carried out in a flight simulator in order to evaluate his visual capacities.

[103] EDUCATION CASE STUDY: STROKE IN A FIGHTER AND AIRLINE TRANSPORT PILOT

Joseph Connolly
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case report describes a pilot who experienced a posterior circulation ischemic stroke. **BACKGROUND:** Ischemic stroke (IS) risk factors of hypertension, diabetes, smoking, dyslipidemia, and obesity are not typically present in USAF aircrew who have IS. Cryptogenic stroke and embolic stroke of undetermined source (ESUS) are the frequent diagnoses after stroke workup. Undiagnosed atrial fibrillation is a concern with cryptogenic stoke or ESUS. Patient foramen ovale (PFO) and cervical artery dissection (carotid/vertebral) are commonly identified causes of IS and TIA in USAF aviators. PFO closure has atrial fibrillation as the most common complication. **CASE PRESENTATION:** A 49 y/o pilot after an 8-hour drive, became dysarthric while eating pizza with their family. The pilot was rushed by their family to the ER, where they were able to walk in. The pilot was noted to have acute dizziness, dysarthria, dysphagia, diaphoresis, and a left facial droop. CT imaging demonstrated a perfusion deficit/occlusion of the proximal P2 segment of the right posterior cerebral artery, right occipital lobe ischemia, and occlusion of the right superior cerebellar artery. Fifty minutes after the onset of dysarthria they received tPA. The stroke work up included CTA head and neck, rhythm monitoring, hypercoagulable work-up, and echocardiogram revealed a right to left intra-atrial shunt at rest. Five months post-stroke the PFO was closed, one month later they had syncope and atrial flutter, 7 months later they had radiofrequency catheter ablation of the caco-tricuspid isthmus, 10 & 11 months later they had episodes of symptomatic atrial fibrillation, 5 months later they were treated with radiofrequency catheter ablation of pulmonary veins (PVAI) and posterior left atrial wall. **DISCUSSION:** This case highlights appropriate work-up for stroke in the young (SITY). RoPE and CHA_2DS_2VASc Scores will be discussed. This case demonstrates complications of PFO closure and etiological diagnostic ambiguity. Finally, USAF Aeromedical waiver recommendation utilizing the USAFSAM AMRAAM will be discussed, and outcome of FAA medical certification will be mentioned.

Learning Objectives

1. The participant will learn about the appropriate work of Stroke in the Young (SITY) in a patient without the usual cerebrovascular risk factors.
2. The participant will know the most common adverse effect of PFO closure.
3. The participant will consider the aeromedical issues in an aviator who has recovered from a stroke, who has a PFO, who has undergone a PFO closure, who had atrial arrhythmias, and has undergone treatment of atrial arrhythmias.

[104] ASTHMA WAIVER POLICY OF THE ISRAELI AIR FORCE

Mor Rittblat, Oded Ben-Ari, Aya Ekshtein, Amir Bar Shai
Israel Air Force Aero Medical Center, Tel Hasomer, Israel

(Original Research)

INTRODUCTION: In the Israeli Air Force (IAF), as in many air forces around the world, individuals with asthma are not eligible for flight academy. However, waiver is considered when asthma onset manifests during or subsequent to the successful completion of flight academy training. The potential risks associated with asthma among aircrew hinge on the assumption that asthma compromises pulmonary function and may lead to sudden incapacitation under extreme conditions, such as high acceleration (G) and hypoxia. The aim of this study was to collect long term data from asthmatic aircrew and to inspect the validity of the current IAF asthma waiver policy. **METHODS:** This was a retrospective cohort study analyzing data from medical records of all active and reserve asthmatic aircrew, who underwent annual medical screening in the IAF Aero Medical Center (AMC) between 2008 and 2022. Data collected included demographic characteristics, flight platform, role in the aircraft, age at onset, treatment, and pulmonary function tests (PFT). **RESULTS:** A total of 30 subjects with a diagnosis of asthma met the inclusion criteria. There was a male predominance (90%). Average age at diagnosis was 32.39±7.66 years. Maximal follow up period was 14 years. High performance (jet) aircrew accounted for almost half (46.66%) of the subject. The majority (66.66%) were treated with inhaled bronchodilators. The average ratio of the forced expiratory volume in the first one second to the forced vital capacity of the lungs (FEV1/FVC) was 74.02% with a minimum of 65%. **DISCUSSION:** Albeit a limited cohort, the results of this study suggest that asthmatic aircrew present stable PFT's over a long follow up period with no medical or flight safety issues. Hence, the current asthma waiver policy of the IAF, which permits jet pilots to fly under chronic inhaled bronchodilators treatment, seems reasonable.

Learning Objectives

1. Pulmonary function tests of asthmatic aircrew remain stable over a long follow up period.
2. Jet pilots under chronic treatment of inhaled bronchodilators perform well with no documented safety events.

Monday, 05/06/2024 ***4:00 PM***
Grand Hall K

[S-21]: SLIDES: BIOMETRICS AND DATABASES FOR SPACE FLIGHT

Chair: Jennifer Fogarty
Co-Chair: Mary Van Baalen

[105] THE NASA OPEN SCIENCE DATA REPOSITORY: BIOMEDICAL DATA, ANALYSIS TOOLS, AND INFORMATIC COLLABORATIONS

Ryan T. Scott[1], Danielle K. Lopez[1], Amanda Saravia-Butler[1], Lauren M. Sanders[2], Samrawit G. Gebre[3], Sylvain V. Costes[3]
[1]*NASA Ames, Space Biosciences Division; KBR, Moffett Field, CA, United States;* [2]*NASA Ames, Space Biosciences Division; BMSIS, Moffett Field, CA, United States;* [3]*NASA Ames, Space Biosciences Division, Moffett Field, CA, United States*

WITHDRAWN

[106] CHANGES IN BLOOD GLUCOSE USING A CONTINUOUS GLUCOSE MONITOR AND BIOMONITORING PARAMETERS OVER THE COURSE OF PARABOLIC AND SUBORBITAL FLIGHT

Dr. Shawna Pandya[1], Yvette Gonzalez[2], Aaron Persad[3], Dr. Jason Reimuller[4], Kellie Gerardi[5]
[1]*International Institute for Astronautical Sciences, Sherwood Park, AB, Canada;* [2]*International Institute for Astronautical Sciences, Berlin, Germany;* [3]*International Institute for Astronautical Sciences, Princess Ann, MD, United States;* [4]*International Institute for Astronautical Sciences, Boulder, CO, United States;* [5]*International Institute for Astronautical Sciences, Jupiter, FL, United States*

WITHDRAWN

[107] MAPPING THE UTILITY OF RADIOGRAPHY AND ULTRASOUND FOR THE NASA IMPACT CONDITIONS LIST

Michael Pohlen[1], Michael Boyle[2], Prashant Parmar[3], Kris Lehnhardt[4], Benjamin Easter[4]
[1]*Stanford University, Palo Alto, CA, United States;* [2]*N/A, San Francisco, CA, United States;* [3]*UTMB, Galveston, TX, United States;* [4]*IPA - NASA JSC, Houston, TX, United States*

(Original Research)

INTRODUCTION: Imaging is central to modern diagnostics, yet to date only ultrasound has been utilized in spaceflight. Advancing the level of care on exploration-class missions and permanent off-world habitats will likely require advanced imaging capabilities to reduce medical risk. The NASA IMPACT tool suite was designed for exploration-class mission probabilistic risk assessment and trade space analysis. Its associated IMPACT Condition List (ICL) includes 120 inflight medical conditions of high concern as established by flight and terrestrial data as well as expert opinion. This study evaluated the clinical utility of ultrasound (US) and radiography (XR) for the diagnosis and management of each of the ICL conditions to identify the conditions for which XR would add value. **METHODS:** For each condition, two reviewers performed a rapid systematic literature review of professional society guidelines and applied subject matter expertise and clinical experience to semi-quantitatively score the utility of US and XR for both diagnosis and management. Diagnostic utility of a modality for a condition was evaluated for the most common clinical presentation(s) of said condition as well as the worst-case scenario and its sequelae as defined by the ICL. Evidence tracing and quality of evidence scores were also recorded. **RESULTS:** Of the 120 ICL conditions, XR diagnostic utility surpasses that of US for 14 (12%) and provides complementary capabilities for an additional 29 conditions (24%). For condition management, XR utility surpasses US for 13 conditions (13%) and provides complementary capabilities for an additional 16 conditions (13%). **DISCUSSION:** Radiography provides diagnostic and management capabilities that surpass or complement ultrasound for over one third of medical conditions of greatest concern on exploration class missions. Specifically, XR provides superior diagnostic ability for conditions involving bony injuries, particularly to the axial skeleton, dental conditions, and certain diseases of the lung parenchyma, among others. It provides superior capability for management of conditions requiring orthopedic reductions, endotracheal tube placement, and drain placement confirmation. This analysis suggests future exploration class missions may consider augmenting the medical system with portable radiography if resource constraints allow, and future work should attempt to quantify the risk reduction provided by this capability.

Learning Objectives

1. Understand the overall degree of utility of imaging in diagnosis and management of the conditions on the IMPACT conditions list.
2. Understand the medical conditions of highest concern on exploration class missions for which radiography provides complementary or superior capabilities compared to ultrasound.

[108] AN ORION MEDICAL KIT SYSTEM OVERVIEW: STARTING POINT TO THE ARTEMIS MISSIONS

Christopher Haas
NASA, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: The Orion Medical Kit System has been designed to provide the base medical functionality for the multi-purpose crew vehicle for up to a 21-day orbital mission. The medical system design was derived from a combination of probabilistic risk assessment tool analysis, NASA subject matter expert review, application of the NASA Spaceflight Human System Standard for Crew Health, and an understanding of the initial mission sets for the Artemis Missions. The ultimate design of the Orion Medical System was also strongly influenced by mass and volume considerations. Thus, the selection of diagnostic capabilities was also driven by the mass and volume footprint of available devices and whether they could be integrated into the vehicle data systems. In this presentation, a high-level description of the selected medical diagnostic and treatment capabilities will be reviewed. Lessons learned from designing the system will be highlighted along with considerations for how the Orion Medical Kit System will need to evolve for Gateway and the lunar exploration components of Artemis. Finally, considerations for future exploration vehicle medical system design and integration will be highlighted.

Learning Objectives

1. The participant will be able to describe the main factors that went into the design of the Orion Medical Kit System.
2. The participant will learn the major components as well as high-level diagnostic and treatment capabilities of the Orion Medical Kit System.
3. The participant will be able to identify challenges to spacecraft medical system design and possible methods for addressing these challenges early on in program development.

[109] SEVEN DAYS OF WHOLE-BODY UNLOADING USING A MG ANALOGUE INDUCES MUSCLE LOSS AS WELL AS REDUCTIONS IN BOTH MUSCLE PROTEIN SYNTHESIS AND BREAKDOWN

Stephen Harridge[1], Tess Morris-Paterson[1], Eleanor Jones[2], Owen Carmichael[3], David Green[4], Zudin Puthucheary[5], Jess Cegeilski[6], Dan Wilkinson[6], Ken Smith[6], Ivana Rosenzweig[1], Atherton Philip[6]
[1]*King's College London, London, United Kingdom;* [2]*University of Nottingham, Nottingham, United Kingdom;* [3]*Pennington Biomedical Research Center, Baton Rouge, LA, United States;* [4]*European Space Agency, Cologne, Germany;* [5]*Queen Mary's University London, London, United Kingdom;* [6]*University of Nottingham, Nottingham, United Kingdom*

(Original Research)

INTRODUCTION: Muscle mass is maintained through a balance between muscle protein synthesis (MPS) and breakdown (MPB). The loss of skeletal mass is one of the major challenges of prolonged exposure to micro-gravity (μG). The present study utilised two tracer approaches with the aim of investigating the effects of 7-days of whole body unloading using a novel ground-based μG analogue on muscle loss and rates of MPS and MPB in young healthy males. **METHODS:** Twelve healthy male subjects (27.3±4.2 years) completed the study. Six weeks prior to unloading each subject underwent a one-week control period. For the unloading intervention period the subjects were asked to lie supine on a hyper buoyancy floatation bed (HBF) for 7 days. For a maximum of 15 mins per day, they were off the HBF (for personal hygiene etc) and were fed a controlled diet during both the control and intervention periods. The deuterium oxide (D_2O) tracer technique with analysis of muscle biopsies taken from the quadriceps was used to study changes in MPS (n=10) over the control and unloading periods. The 3-methylhistidine (3-MH) technique was used to measure MPB (n=12) across the whole body and changes in muscle mass of the upper part of the lower limb were measured using Magnetic Resonance Imaging (n=12). **RESULTS:** Muscle mass of the upper leg was reduced by 3.4% (10.4±1.8 vs 10.0±1.8 kg; p<0.01,

mean±SD; paired t-test) after the unloading period. MPS (expressed as myofibrillar fractional synthetic rate) was significantly lower after the unloading compared to the control period (1.21±0.18 vs1.41±0.21%•d^{-1}; $p<0.01$). The rate of MPB was also significantly lower for the unloading period compared to the control period (0.043±0.031 vs 0.062±0.23 h^{-1}; $p<0.05$). **DISCUSSION:** The finding that unloading induced a reduction in muscle mass and MPS is not unexpected in the light of results from previous studies. However, the observation that MPB was also reduced is a novel observation which provides new insights into the processes driving unloading-induced muscle atrophy in healthy humans.

Learning Objectives

1. The audience will learn about the effects of micro gravity and unloading on human skeletal muscle mass.
2. The audience will learn about the use of tracer techniques to measure rates of muscle protein synthesis and breakdown in humans.
3. The audience will learn that 7 days of whole body unloading, which induces a loss of muscle mass, is accompanied by a reduction in muscle protein synthesis and also, somewhat surprisingly, by a reduction in muscle protein breakdown.

[110] THE EFFECT OF 60-MINUTE HEAD-DOWN TILT ON THE CROSS-SECTIONAL AREA OF THE INTERNAL JUGULAR VEIN

Syeda Yasmin Zaman[1], Matteo Fois[2], Stefania Scarsoglio[2], Luca Ridolfi[2], Ana Diaz-Artiles[1]

[1]*Texas A&M University, College Station, TX, United States;* [2]*Politecnico di Torino, Turin, Italy*

(Original Research)

INTRODUCTION: Exposure to weightlessness causes a headward fluid shift that may alter venous hemodynamics, compromising internal jugular vein (IJV) flow and possibly leading to partial or complete thrombosis. To better understand the early response of the IJV to headward fluid shift, this study aims to characterize the cross-sectional area of the IJV (A_{IJV}) during 60 minutes of exposure to 6° head-down tilt (HDT). **METHODS:** Twelve subjects (6F/6M, 25.8 ± 3.8 years old) were exposed to 60 minutes of 6° HDT using a tilt table. Measurements of the A_{IJV} (left and right side) were collected using ultrasound at the start (i.e., 5 minutes into) and end of exposure. In addition, mean arterial pressure (MAP), heart rate (HR), and cardiac output (CO) were also collected using Finapres NOVA (MAP and HR) and Innocor (CO) devices. Immediately before the tilt test, baseline data were also collected at 80° head-up tilt (HUT). Data at the start and end of the tilt test were analyzed using a paired t-test (one-sided). Data are presented as mean ± standard deviation. **RESULTS**: At 80° HUT, A_{IJV} = 4.5 ± 6.1 mm^2 (left and right side averaged), MAP = 82.4 ± 13.4 mmHg, CO = 3.7 ± 1.1 l/min, and HR = 100.8 ± 14.3 bpm. During the 60 minutes of 6° HDT, the A_{IJV} significantly increased from 57.7 ± 31.5 to 83.6 ± 33.1 mm^2 ($t(11)=5.5$, $p<0.001$), MAP significantly increased from 74.3 ± 12.1 to 81.9 ± 11.6 mmHg ($t(11)=4.7$, $p<0.001$), and CO significantly increased from 4.8 ± 1.4 to 5.7 ± 1.2 l/min ($t(11)=2.1$, $p=0.028$). HR did not significantly change ($HR_{initial}$ = 74.8 ± 14.0 bpm, HR_{end} = 73.4 ± 10.3 bpm, $p=0.23$). **DISCUSSION:** The responses of the A_{IJV} were characterized during early exposure to headward fluid shift, showing a steady increase during this time frame. MAP and CO were found to increase while HR remained stable. As commercial spaceflight operates within similar short-term timelines, these results provide a better understanding of early hemodynamic responses and contribute towards the protection of humans in these microgravity environments. These results can also inform the development of future countermeasures.

Learning Objectives

1. The audience will learn about headward fluid shift and how it affects the internal jugular vein.
2. The audience will learn about how acute exposures to ground-based analogues of weightlessness elicit hemodynamic responses.

Monday, 05/06/2024 ***4:00 PM***
Grand Hall GH

[S-22]: PANEL: UPDATES IN OPERATIONAL VISION RESEARCH

Chair: Adam Preston
Co-Chair: Micah Kinney

PANEL OVERVIEW: *Aircrew rely heavily on their visual system to maintain situational awareness and aircraft control during critical phases of flight and operational events. This panel will discuss updates in a range of operational vision research topics to include aviator eye tracking and machine learning, color vision, and the development of a virtual-reality (VR) based laser dazzle training. Presentation (1) will open with a discussion on the development of a deep learning eye tracking model capable of identifying suboptimal scan patterns in real time in pilots flying a Texan T6A flight simulator. Presentation (2) will discuss findings that suggest clinical electrodiagnostic measures suggest adaptive changes in color vision performance with color-correcting lens wear. Presentation (3) will discuss color vision impacts of a recently available FAA-approved commercial laser eye protection spectacle developed in partnership with the Department of Defense. Presentation (4) will discuss color vision discrimination modeling based on psychophysical research on aircrew laser eye protection and clinical color vision tests. Presentation (5) will discuss the development of a VR-based laser dazzle and aftereffects simulator that can be incorporated into existing and future flight simulators for training, education, and response development.*

[111] REAL-TIME DETECTION OF SUBOPTIMAL SCAN PATTERNS USING DEEP LEARNING

Lucas Haberkamp, Roy Allen Hoffman, Michael Reddix, Stephanie Warner

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

(Original Research)

INTRODUCTION: A growing body of research focused on aviator scan patterns suggests that 'normal' scanning behavior is context dependent. Scanning strategies are influenced by the phase of flight, environmental conditions, and individual variability. Suboptimal visual scanning can negatively impact an aviator's situational awareness and pose risks to flight safety. To address this concern, we present a cutting-edge solution: a deep learning model that considers the broader flight context to detect suboptimal scan patterns. **METHODS:** Fourteen aviators completed two flights in visual meteorological conditions using a Texan T6A flight simulator. The flight phases included takeoff, heading and altitude changes, constant rate turns, and landing. We simultaneously collected flight state variables and eye-tracking data to extract gaze transition entropy (GTE), fixation rate, and out-of-the cockpit proportional dwell time. We pretrained a recurrent neural network to generate predictions for gaze metrics and flight state variables conditioned on 25 seconds of historical data. After manual annotations of normal versus anomalous scanning, we fine-tuned our model to classify anomalous gaze behavior using each aviator's first flight for training and the second flight for validation. We analyzed the performance of our deep learning model using precision and recall, common classification metrics for evaluating false positives and negatives. **RESULTS:** Precision was 1.0 and recall was 0.96 for both GTE and fixation rate. For out-the-cockpit proportional dwell time, the precision was 0.98 and recall was 0.94. The model demonstrated contextual awareness. For example, low GTE (predictable scanning) while on glide slope were correctly flagged as anomalous compared to similar GTE values that were deemed 'normal' during final approach. **DISCUSSION:** Our results underscore the deep learning model's ability to discern flight scenario-specific norms. A limitation of our study was the small dataset.

Utilizing a larger dataset has the potential to boost classification performance further. Future research exploring alternative neural network architectures and data streams may yield improved results and enable monitoring of additional physiological responses. Overall, our deep learning approach provides a framework for automatically detecting suboptimal scanning behavior and holds the potential for enhancing aviator training techniques and in-flight physiological monitoring systems.

Learning Objectives

1. Discuss a novel deep learning framework for detecting suboptimal scanning behavior.
2. Provide insights into how aviator training techniques and in-flight physiological monitoring systems can benefit from incorporating deep learning.

[112] VEP METRICS OF COLOR CORRECTING LENSES (CCL): A RANDOMIZED CLINICAL TRIAL

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

(Original Research)

INTRODUCTION: Color vision deficiency (CVD) can reduce performance and delay response time in cue-limited settings. Hereditary congenital CVD is regarded as non-progressive and predicated on a shift in red (L) or green (M) cone sensitivity or the absence of either cone. Our purpose is to describe objective improvement in CVD performance wearing CCLs (www.enchroma.com) as well as potential for neuro-adaptive change. **METHODS:** 20 CVDs (3 female, 17 male, 8 protan, 12 deutan) provided written informed consent in accord with our IRB-approved protocol (randomized, double-blind, placebo-controlled crossover clinical trial, clinicaltrials.gov/study/NCT05463016). CVD was confirmed by Ishihara and anomaloscope testing. Subjects wore either CCLs or neutral lenses (same luminance transmission equally across spectrum, ND) for 7 days, tracking daily indoor and outdoor wearing time and then crossed over to the lenses not worn in the first session. Cone-specific visual evoked potentials (VEP) were recorded on the first and last days of each 7-day session with and without the assigned filter (4 data sets per subject). Data were distributed normally. Repeated-measures ANOVA with post-hoc t-tests were used for analyses (Bonferroni correction). **RESULTS:** On day 1 mean VEP amplitude for the defective cone type (DC) was significantly higher with CCLs (7.4 μV) vs. without CCLs (4.5 μV; mean improvement 2.9 μV or 65%, 95% CI 1.2 - 4.5, $P = 0.003$, n=19). Mean DC VEP latency was shorter with CCLs (40.6 msec.) vs. without (47.5) but neither this immediate effect nor VEP changes (on day 1 vs. day 7 of CCL wear) achieved significance. In contrast to CCL wear, there were no immediate or 7-day effects of ND lenses on VEP amplitude or latency ($P > .65$). **DISCUSSION:** Initial results from the first randomized clinical trial of CCLs showed 65% improvement in cone-specific VEP amplitude with a latency trend but no definitive evidence of neuro-adaptive change over a 7-day period. Since the CCLs were prototypes that have since been improved offering greater light transmission and enhanced CVD performance based on initial testing, it is conceivable that the new lenses, and further analysis of the myriad data collected in our clinical trial, will reveal both immediate and longer-term neuro-adaptive improvements in CVD.

Learning Objectives

1. The audience will learn about Visually Evoked Potentials and how they differ in Color Vision Deficient vice Color Normal subjects.
2. The participants will be able to understand the importance of cone-specific testing for indentifying type and severity of Color Vision Deficiency.

[113] HUMAN FACTORS EVALUATION OF LASER EYE PROTECTION SPECTACLES FOR CIVIL AVIATION

David Newton[1], Ted Mofle[2], Peter Hu[2]
[1]*FAA, Oklahoma City, OK, United States;*
[2]*Cherokee Nation 3-S, Oklahoma City, OK, United States*

(Original Research)

INTRODUCTION: Laser strikes pose a direct threat to aviation safety and air traffic coordination. They can cause a variety of negative physiological and psychological effects on pilots, including glare, flash blindness, afterimages, and startle. Laser eye protection (LEP) spectacles are designed to mitigate these effects by attenuating the light emitted by handheld lasers. While LEP spectacles are effective in mitigating the impacts of laser strikes on pilots, psychophysical assessments reveal that the attenuating properties of the lenses can alter color perception. As such, wearing the LEP spectacles may impact pilots' ability to use color-coded information and maintain awareness of critical visual information during flight. **METHODS:** Fourteen Instrument-Rated pilots with normal color vision completed flights with LEP spectacles in a variety of flight environments in a fixed-base flight simulator. During the flights, objective measures of pilot performance were taken and compared to baseline flights where LEP spectacles were not worn. Additionally, participants completed questionnaires and interviews to provide subjective feedback on use of the LEP spectacles. **RESULTS:** Wearing LEP spectacles largely did not affect pilots' ability to follow navigational and flight guidance information, perceive and comprehend color-coded alphanumeric information during flight, or detect and respond to system malfunctions. Questionnaire and interview responses from pilot participants revealed that the LEP spectacles were compatible with displays, controls, and instruments inside the aircraft, and do not substantially hinder visibility of environmental features such as airfield lighting. **DISCUSSION:** LEP spectacles—a promising tool for reducing the risks associated with laser strikes—are likely compatible with the civil aviation flight deck and associated pilot duties. Yet, there are opportunities to increase awareness of LEP technology among the pilot community and develop recommendations for their use during flight. Increased use and acceptance of LEP spectacles, combined with an established framework for their use, could potentially reduce the risks of laser strikes to flight safety.

Learning Objectives

1. The perceptual effects of wearing LEP spectacles likely does not translate to operationally-significant effects on performance for pilots with normal color vision.
2. It is likely that pilots' ability to perform normal pilot duties is not negatively impacted when wearing LEP spectacles.

[114] A METHOD FOR MODELING FM-100 HUE DATA THAT ENABLES CLINICAL AND APPLIED LABORATORIES TO ESTMATE CLASSIC WAVELENGTH DISCRIMINATION

Vincent Billock[1], Adam Preston[2], Michael Reddix[2]
[1]*Leidos, Inc. at Naval Medical Research Unit - Dayton, Wright-Patterson AFB, OH, United States;* [2]*Naval Medical Research Unit - Dayton, Wright-Patterson AFB, OH, United States*

(Original Research)

INTRODUCTION: Although rigorous studies of color discrimination are based on bipartite monochromatic stimuli, few laboratories are so equipped. Most clinical and applied laboratories employ the Farnsworth-Munsell 100 hue test, a cap arrangement task that uses many pigmented broad-spectral desaturated stimuli. Our laboratory – which employs the FM-100 to study color vision of subjects wearing laser eye protection – sought to bridge this gap between monochromatic and broadband wavelength discrimination. **METHODS:** Experimental work was approved by the NAMRU-D IRB. 20 color normal subjects were measured using the FM-100 hue arrangement test, which uses pigments of roughly equal

subjective desaturation. The cap dominant wavelengths are known and colorimetric purity was computed from the dominant wavelength and CIE coordinates of each cap. The FM-100 hue data were transformed into an equivalent wavelength discrimination function (spanning 445-633 nm) by compensating for the known (Tyndall) effects of colorimetric purity on discrimination. We averaged the results for the 20 normal observers and fit the data with the Boynton (1979) model for wavelength discrimination. For comparison we generated an average observer for monochromatic stimuli by averaging 9 observers from 4 laboratories that used monochromatic stimuli. **RESULTS:** After compensating for the Tyndall effect, the FM-100 hue test is capable of resolving wavelength discriminations equivalent to those produced for monochromatic stimuli. Moreover, the average purity-compensated FM-100 hue wavelength discrimination function closely resembles the average observer wavelength discrimination function that we curated from the literature. **DISCUSSION:** The purity-compensated FM-100 hue wavelength discrimination function allows any clinical or applied laboratory to study wavelength discrimination in its original context and to use the models developed for classic wavelength discrimination. The next step for our laboratory will be to apply this to wavelength discrimination for normal and anomalous trichromats wearing laser eye protection.

Learning Objectives

1. Understand that desirable but difficult to measure experimental data (wavelength discrimination) can be obtained from a widely available test (FM 100 Hue), by incorporating an additional experimental finding (he Tyndall effect).
2. Understand that transforming FM 100 hue results into wavelength discrimination makes it possible for clinical and applied laboratories to use models of wavelength discrimination developed for monochromatic data and to compare data taken by different means.

[115] SIMULATION OF LASER DAZZLE AND LASER EYE PROTECTION EFFECTS IN VIRTUAL REALITY

Wesley Kinerk, Julie Lovell, Lyndsey Ferris
Air Force Research Laboratory, Joint Base San Antonio-Fort Sam, Houston, TX, United States

(Original Research)

INTRODUCTION: The widespread availability and increasing power of hand-held lasers has driven a rise in the threat of vision effects, including temporary effects such dazzle (i.e. glare) and afterimages. For example, there were 9,457 aircraft illumination events reported to the U.S. Federal Aviation Agency in 2022. The 711th Human Performance Wing's Bioeffects Division has created a simulation of transitory laser effects on vision in virtual reality (VR), to include dazzle and afterimages and is also simulating laser eye protection (LEP) effects such as shifts in color vision perception (both before and after adaptation by the human visual system) and the mitigation of dazzle effects when viewed through appropriate LEP. **METHODS:** An experiment with 16 participants was performed under Air Force Research Laboratory Institutional Review Board protocol FWR 20230100H comparing the outcomes of an orientation discrimination task (Landolt Cs) conducted in VR with the results of a similar task performed in the presence of real laser dazzle with a 532 nm (green) wavelength. The independent variables included laser irradiance at the observer, background luminance, and eccentricity of the target relative to the laser source. **RESULTS:** The technical limitations of currently available VR headsets make it necessary to create image adjustments to compensate for the headset's inability to replicate high irradiance and high background luminance levels. After making those adjustments, the extent of the visual field obscured by the VR laser dazzle effect generally correlated well with that obscured by real laser dazzle with the highest amount of variation in data explained at the 6 cd/m^2 background luminance (r^2=0.99), followed by the 100 cd/m^2 background (r^2=0.90), and the 1000 cd/m^2 background (r^2=0.76). **DISCUSSION:** The overall goal of this effort is to create validated laser dazzle and LEP effects packages that can be incorporated into existing and future VR flight simulators. These implementations will enable training, education, and development of tactics in response to laser exposures that are difficult or impractical to accomplish with physical lasers and live training.

Learning Objectives

1. The audience will learn about the potential applications of simulating realistic laser dazzle in extended reality training and education environments.
2. The audience will learn about the technological challenges and limitations of simulating laser dazzle as well as possible future directions for this area of investigation.

Monday, 05/06/2024 ***4:00 PM***
Grand Hall I

[S-23]: PANEL: INTERNATIONAL COOPERATIVE ENGAGEMENT – PROGRAM FOR POLAR RESEARCH HUMAN PERFORMANCE WORKING GROUP OVERVIEW

Chair: Bethany Shivers

PANEL OVERVIEW: *BODY: This panel provides an overview of the International Cooperative Engagement – Program for Polar Research (ICE-PPR) Human Performance Working Group (HPWG). The ICE-PPR is a multi-national program, led by the U.S. Chief of Naval Research, established to provide a forum for collaborative polar research and resource sharing. There are four working groups within the ICE-PPR construct (Environmental, Human Performance, Platforms, and Situational Awareness). The first presentation, from the Office of Naval Research, will provide an overview of ICE-PPR construct. The second presentation, from the Naval Health Research Center, will discuss nutrition and hydration needs for optimal Warfighter performance in polar environments. The third presentation, from the Naval Medical Research Unit – San Antonio, will provide an overview of the sub-working group on Polar Medicine and research related to combat casualty care in polar environments. The fourth presentation from the Naval Clothing and Textile Research Facility, will discuss protective clothing capability gaps and developmental programs. Finally, the fifth presentation, from the Air Force Research Laboratory, will provide an overview of the Cognitive Performance sub-working group and polar environmental effects on instrumentation.*

[118] ICE PPR OVERVIEW

Patrick Mason
Office of Naval Research, Arlington, VA, United States

(Original Research)

BACKGROUND: Future military operations are expected to push further into arctic environments. This will require militaries to identify and address knowledge and capability gaps pertaining to optimizing and sustaining human performace and medical care in extreme cold and austere conditions. **OVERVIEW**: Led by U.S. Chief of Naval Research, the International Cooperative Engagement Program for Polar Research (ICE PPR) was established in November 2020 and pertains to research, development, testing, and evaluation (RDT&E) to improved capabilities for successful and safe operations in Polar areas. The seven participating nations are: Canada, Denmark, Norway, Sweden, Finland, New Zealand, and United States. All Services and Government Agencies in these nations are invited to participate. ICE PPR creates a collaborative forum to initiate, conduct, and manage polar RDT&E projects, as well as exchange information (up to SECRET) in order to harmonize defense and national security requirements. There are four ICE PPR Working Groups (Environmental, Human Performance, Platforms, and Situational Awarenness). **DISCUSSION**: ICE PPR provides a platform for participating nations to conduct collaborative research, share resources, and leverage capabilities in order to optimize

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*