(Education - Program/Process Review)

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

Learning Objectives

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

Tuesday, 05/07/2024 ***4:00 PM***
Grand Ballroom A

[S-41]: SLIDES: BONES, MUSCLES AND CENTRIFUGES - OH MY

Chair: Jennifer Fogarty
Co-Chair: Megan Gallo

[222] HEAD DOWN TILT BED REST STUDIES AND EYE EXAMINATIONS FOR TEST SUBJECTS SAFETY

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(Education - Program/Process Review)

BACKGROUND: Prolonged head-down tilt bed rest (HDTBR) is frequently employed as an analog to study the human physiology changes that occur during spaceflight, particularly Spaceflight Associated Neuro-ocular Syndrome (SANS). We conducted four HDTBR campaigns to investigate ocular changes and potential SANS countermeasures. To ensure the safety of test subjects and the quality of data, we established specific exclusion criteria and implemented safety examinations. **OVERVIEW:** 39 test subjects underwent a 30-day period of strict HDTBR. Comprehensive ocular assessments were conducted at baseline and during the immediate recovery phase following HDTBR. This included measurements of visual acuity, refraction, visual field, applanation tonometry, slit lamp, optical coherence tomography (OCT) and fundoscopy. Measurement of intraocular pressure (IOP) and near visual acuity was added at day 2, 4, 17 and 30 of the HDTBR period. One test subject developed a retinopathia centralis serosa and was subsequently excluded during baseline examination. Another showed a retinal hole in the periphery which was detected with dilated fundoscopy during baseline examination and was treated by laser before bedrest started. Two eyes of two participants showed a reduction of two and three lines of near visual acuity at day 2 of bed rest. After bed rest, near visual acuity of one eye showed one line of reduction, while the other eye was back to baseline. There was no significant hyperopic shift in refraction and no optic disc edema in these eyes. For all participants, IOP during bed rest had a range of 12.2 to 27.6 mm Hg, with the highest values at day 4 and 17. **DISCUSSION:** The observed increase in IOP highlights the importance of IOP safety measures during HDTBR. Near visual acuity testing does not give enough information concerning hyperopic shift and reduced eye length due to different influences on near vision and a lack of hyperopic shift in bed rest. We emphasize of conducting a comprehensive eye examination with visual acuity testing, applanation tonometry, visual field testing, OCT, slit lamp and dilated fundoscopy. Additionally, the exclusion of eye pathologies is important to ensure test subjects safety during HDTBR.

Learning Objectives

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

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

Ryan Anderton[1], Thomas Smith[2], Ross Pollock[2], Joseph Britton[3], Nicholas Green[3], Daniel Hendriksen[3]
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(Original Research)

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

Learning Objectives

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

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

Samantha King, Rebecca Blue
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(Original Research)

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

Learning Objectives

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

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

Vaishnavi Rathod[1], Darshankumar Raval[2], Shahin Khan[3], Shashwat Mallik[3], Musharrafah Ansari[3], Het Contractor[3], Milauni Dave[3], Devang Gohel[3], Kajal Patel[3], Leigh Speicher[4]
[1]*Parul Institute of Medical Sciences, Vadodara, India;* [2]*Mayo Clinic, Jacksonville, FL, United States;* [3]*Government Medical College, Baroda, Vadodara, India;* [4]*Mayo Clinic, Jacksonville, FL, United States*

(Education - Tutorial/Review)

INTRODUCTION: Microgravity in space has significant detrimental effects on the musculoskeletal system (MSK), including bones, muscles, and intervertebral discs (IVD). Studies on astronauts, bed-rest patients, and animals have consistently shown a decrease in trabecular and cortical bone density, muscle atrophy, and an increased risk of IVD herniation. **TOPIC:** The bone density loss is more evident in weight-bearing bones, especially those of the lower limb. This is attributed to imbalances between osteoblast and osteoclast activity, changes in integrin signaling mechanisms, and mitochondrial disruption. Moreover, microgravity leads to imbalances in calcium-phosphorus homeostasis, with increased urinary calcium and bone resorption markers, and decreased bone formation markers. These changes are also heavily influenced by the duration of microgravity. Muscle atrophy is another consequence of microgravity, affecting various muscle groups, especially the multifidus and ankle extensors. Changes in muscle volume are attributed to a reduction in the Daily External Loading Stimulus and altered metabolism of muscle fibers, along with a decrease in the capillaries supplying each fiber. Long-term exposure to microgravity also results in a reduction of muscle strength, with calcium levels in muscle fibers playing a critical role. IVDs experience changes in volume and hydration due to unloading in microgravity. Hence, astronauts are 4.3 times more likely than the general population to experience disc herniation. Fluid flow and nutrition to the discs are affected, similar to the degeneration seen in aging discs. Diurnal changes in fluid flow are disrupted in space. Previous high-performance jet pilot training seems to be protective. **APPLICATION:** Countermeasures, like exercise protocols, are essential to mitigate the adverse effects of microgravity. Aerobic and resistive exercises, especially personalized cycling exercises, have been found effective in preserving muscle mass, muscle strength, and bone density. However, it remains challenging to expel excess fluid from intervertebral discs in a microgravity environment. Newer exercise regimes are required because even though the current ones are effective, they are not adequate as our astronauts continue to suffer from MSK pathologies post-flight. Further research is needed to better understand the mechanisms underlying these effects and to develop targeted countermeasures to protect the MSK during spaceflight.

Learning Objectives

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

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

Nathan Skelley[1], Lisa MacFadden[2], Clint Boerhave[3]
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(Original Research)

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