National Aeronautics and Space Administration

THE LIFETIME SURVEILLANCE OF ASTRONAUT HEALTH

Newsletter

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This edition of the LSAH newsletter illustrates how LSAH utilizes medical coding and Big Data tools to fulfill data requests and occupational surveillance efforts. When those efforts evolve into scientific papers, LSAH conducts attributability reviews to protect astronauts' medical privacy.

LSAH Data Happenings

Matthew Koslovsky, Ph.D.

We are well into the era of Big Data. Companies, government agencies, and academic institutions are equipping themselves to transform massive amounts of data into knowledge to drive innovation, policy, and decision-making. Big Data are described as having large scale or volume, coming in a variety of forms, being collected continuously, and/or having various levels of uncertainty in its quality. To manage and interpret Big Data, data analysts require robust data storage, processing, visualization, and analysis techniques. Although the NASA astronaut corps is a small population, it generates Big Data.

One of the primary roles of LSAH is to curate astronaut medical data collected for clinical purposes, including medical data collected surrounding a mission and LSAH physical exams. These data are a valuable resource that contains a wealth of information regarding the physiological changes associated with spaceflight and astronaut training. This information is pertinent to NASA's preparation for long-duration missions outside of low-Earth orbit as well as supporting astronauts' long-term health. In order to help mitigate astronauts' short- and long-term health risks, LSAH has been pursuing innovative strategies to compile, maintain, and analyze these data to ensure its value is fully extracted and preserved.

Currently, LSAH is ingesting astronaut data into an advanced data analytics platform (Information Management Platform for AnaLytics & Aggregation or IMPALA) which will enable our team to efficiently find, manage, and process these data. An early success with the platform is a nomogram that LSAH prepares for crew surgeons, which provides a visual summary of data from 10 different ocular health tests. This visualization can now be prepared using IMPALA in a quarter of the time previously required. Additionally, our team is applying statistical and machine learning techniques, developing novel analytical methods, and collaborating with academia and industry to generate new hypotheses regarding the effects of spaceflight on human physiology. For example, we are developing an interactive image-processing tool that will help NASA automate the extraction of hemodynamic data from Doppler ultrasounds. This is currently an extremely manual, subjective task, so the image-processing tool will improve the accuracy and consistency of the data and speed up delivery time.

Moving forward, our enhanced ability to work with astronaut data will initiate new occupational surveillance activities and research studies and expand our overall understanding of the effects of spaceflight on humans. As custodians of these data, LSAH is committed to preserving its integrity, translating it into knowledge, and sharing the results back to the astronaut corps.

Back pain from microgravity: Changes in intervertebral discs or muscular atrophy?

Caroline Schaefer, MPH

A study published in Spine in 2018 by Chang et al. investigated the mechanisms by which microgravity impacted the spine. The study sought a better understanding of low back pain, in-flight and post-flight risk of disc herniation, and to provide insights into the development of in-flight countermeasures that focus on maintaining astronaut spine health[1]. While previous research both in microgravity and in bed rest simulations indicates that unloading causes "spinal lengthening" and spinal stiffness due to swelling of unloaded discs, those studies did not show lumbar disc height changes following spaceflight of either short (< 30 days) or long (~ 6 months) duration.[3, 4]

This longitudinal study followed six NASA crewmembers whose lumbar spine anatomy and biomechanics were quantified before and after 6-month ISS missions. Among the measurements collected pre- and post-flight (L-30 and R+1/3) using MRI were angle of lumbar curvature, individual disc and vertebral wedging (when one side of the vertebral body is lower than the other side, creating a wedge), disc water content, disc degeneration, and measures of lumbar muscle size and density.

Results indicated increased back flattening in all six subjects after flight. Changes in the cross sectional area of the dense multifidus muscle (deep spinal muscle, very close to the midline) strongly correlated with changes in lumbar curve angle ("lordosis") and active intersegmental flexion-extension range of motion (FE ROM, range in degrees of the area between spinal segments along the x-axis) (r2= 0.86 and 0.94, respectively). Disc water content did not differ systematically from pre - to post-flight. This was consistent along each measured disc and when evaluated together. Two crewmembers who had pre-flight presence of vertebral end plate irregularities were the only ones to report chronic low back pain one year post-flight, with one of those crewmembers also reporting a disc herniation at L4-L5.

The study's authors concluded that paraspinal muscle atrophy of the multifidus was associated with post-flight decreases in lumbar lordosis and FE ROM. The multifidus (see Figure 1) is a deep spinal muscle that provides stability and stiffness, which reduces the degeneration of joint structures and aids in body positioning and movement to ensure accurate spine positioning. Multifidus atrophy has been linked terrestrially to chronic low back pain, likely due to changes in posture and motion. The results from the current research indicate that lumbar flattening is associated with multifidus atrophy rather than disc swelling as previously hypothesized. Reduced lumbar curvature caused by muscular atrophy may lead to spinal lengthening due to postural changes. There is also an increased risk of herniation as a result of increased compressive disc loads and potential for exceeding ROM in flexion. Spinal flattening and increased stiffness both increase injury risk, especially in those with preexisting vertebral conditions. These results can be translated to deconditioned spines terrestrially and should be used to develop countermeasures targeting the multifidus muscles.

Numerous efforts are underway to understand better spaceflight-related issues with the spine and supporting tissues. From Human Research Program investigations like this one, to clinical activities such as the January 2018 Space Medicine Operations Back Pain Summit, NASA hopes to develop more effective countermeasures to support spine health throughout an astronaut's active career and into retirement.

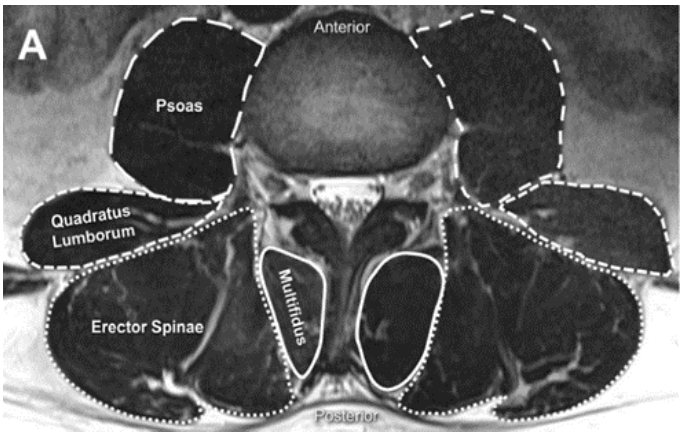

Figure 1. lumbar paraspinal muscles[2]

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The Human Research Program Investigators' Workshop: Integrating medical and research data to inform the spaceflight community

Jacqueline Charvat, Ph.D., & Amber May, BS

The Human Research Program (HRP) is dedicated to discovering the best methods and technologies to support safe, productive human space travel.[1] A valuable resource used in support of this goal is the astronaut health data collected and stored in the LSAH data archives. In January of 2018, HRP hosted funded investigators, students, support personnel, and other interested individuals at the annual Investigators' Workshop (IWS). Over a span of four days at the Galveston Convention Center, this workshop displayed the vast amount of spaceflight and ground analog research that NASA and National Space Biomedical Research Institute (NSBRI*) researchers have accomplished over the last year. The Investigators' Workshop provides a forum to apprise the community of ongoing research, encourage cross-disciplinary interaction, and highlight research that the HRP leverages through national and international collaborations.

Several plenary sessions highlight key themes of the meeting, and shorter presentations on research results are generally arranged by risk focus areas of the human system. The research work presented reflects the strategic path to risk reduction developed by each HRP Element including Human Factors and Behavioral Performance, Human Health Countermeasures, Space Radiation, and Exploration Medical Capability. Element sessions include research data collected from laboratories ground analog [e.g., Human Exploration Research Analog (HERA), bed rest, NASA Space Radiation Laboratory (NSRL)] and spaceflight studies as well as results from modeling and other related efforts. HRP IWS also provides a spotlight for junior investigators. The HRP Graduate/Post-doctoral Fellow Poster Contest allows student researchers to bring their fresh perspectives and unique expertise to aid the mitigation of human spaceflight risks. The contest winners for 2018 were:

Graduate Student Category:

- Jordan Dixon, University of Colorado Boulder, "Preliminary Validation of the Wheelchair Head Immobilization Paradigm as an Analog for Post-Flight Sensorimotor Impairment"
- Heather Hava, University of Colorado Boulder, "In-Flight Fruit and Edible Algae Production Through a Novel Hybrid Bio-Wick and Photobioreaction System"
- Brett Janis, University of Louisville, "Dry-Preservation of Red Blood Cells for Storage at Ambient Temperatures"

Postdoctoral Fellow Category:

- Jeannie Bailey, University of California, San Francisco, "Risk of Intervertebral Disc Damage after Prolonged Space Flight"
- Lonnie Petersen, University of California, San Diego, "Mobile Negative Pressure Suit as an Integrated Countermeasure"
- Vivekanand Vimal, Brandeis University, "Predicting Individual Differences in Learning Manual Control of Attitude Stability in a Space Flight Analog Environment"

For more details of 2018 HRP IWS meeting contents, click here to view the program.

**The NSBRI ended in 2017 after 20 years. The successor consortium, also based at the Baylor College of Medicine in Houston, is called the Transitional Research Institute for Space Health (TRISH).*

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Protecting astronaut medical privacy: Review of presentations and publication for attributability

Mary Wear, Ph.D.

Retrospective data, or data that has been previously collected, can be a valuable resource for researchers. Retrospective astronaut data can be requested from two NASA archives: Specifically, the Lifetime Surveillance of Astronaut Health (LSAH), which maintains astronaut medical data and the Life Sciences Data Archive (LSDA), which retains astronaut and ground subject research data. Researchers can submit a request for retrospective data at https://lsda.jsc.nasa.gov/Request/dataRequestFAQ, where the process is described in detail. Researchers may request pooled data (data grouped so individual identity cannot be determined), de-identified data (data set containing raw data is provided but variables are grouped so that individuals cannot be identified) or attributable data (data set contains raw data that includes personally identifying information). When attributable (and in some cases de-identified) data is required, researchers must obtain the consent of each participant.

Personally identifiable information (PII)[1] is any data that can be used to identify an individual either on its own or in combination with other information. This includes medical, educational, financial and employment information. Astronaut medical and research data can be PII and must be protected. Federal laws, regulations and policies apply to protection of PII including:

- NASA 10HIMS (Health Information Management System)[2]
  - Data collected for medical purposes
- NASA 10HERD (Human Experimental & Research Data)[3]
  - Data collected for research purposes
- HIPAA Public Law 104-191[4]
- The Privacy Act of 1974 5 U.S.C. § 552a[5]
- The Common Rule 45 CFR part 46[6]
- Genetic Information Non-Discrimination Act (GINA) Public Law 110-233[7]

To comply with the above federal laws and regulations, any materials that use astronaut research and medical data must be reviewed for attributability before being released to the public domain. When researchers request attributable or potentially attributable data, they sign a Data Use Agreement that explicitly states this requirement. All final versions of abstracts, presentations, posters, and manuscripts must be reviewed by LSAH and/or LSDA personnel prior to being published in the public domain. If material undergoes multiple revisions (e.g., journal editor comments), each new version must also be reviewed by LSAH/LSDA, prior to re-submission to the journal. The purpose of this review is to ensure that no PII is included in materials that are presented in a public venue or posted to the public domain. This review is essential to protect astronaut confidentiality/privacy and remain in compliance with the informed consent an astronaut gives prior to participating in research studies.

Astronauts are public figures and many details of their careers and personal lives are readily available from sources as varied as Wikipedia, scientific articles, news media reports, NASA.gov, and astronaut blogs. Many characteristics that trigger concerns regarding attributability, either alone or in combination, are easily found in these sources. Examples include: astronaut age (current, at selection, at launch), sex, extravehicular activity (EVA) experiences, mission details including type of vehicle flown and date of launch/landing, special inflight activities, time between missions, number of missions flown or cumulative number of days in space, and space agency affiliation. For example, on January 11, 2018, The Most Extreme Human Spaceflight Records[8], was published and listed many extremes (first, oldest and youngest, shortest and longest, etc.) in a single, easy to find article.

At the 2018 NASA Human Research Program Investigators' Workshop[9], LSAH gave a keynote presentation to ensure that the research community recognizes the importance of protecting astronaut privacy, and understands how to meet the requirement for attributability review. LSAH and LSDA are firmly committed to the regulatory and ethical obligations to protect astronaut privacy.

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[2]NASA 10HIMS (Health Information Management System), 2007 (link).

[3]NASA 10HERD (Human Experimental & Research Data), 2007 (link).

[4]Health Insurance Portability and Accountability Act of 1996, Public Law 104-191 (link).

[5]The Privacy Act of 1974 5 U.S.C. § 552a. (link)

[6]Federal Policy for the Protection of Human Subjects ('Common Rule'). 45 CFR part 46 (link).

[7]Genetic Information Non-Discrimination Act (GINA). Public Law 110-233 (link).

[8]Wall, Mike. The Most Extreme Human Spaceflight Records. Space.com, January 11, 2018 (link).

[9]Wear M, Charvat J, Lee L, Babiak-Vazquez A, Mason S, Van Baalen M, Murray J. Protecting Astronaut Medical Privacy: Review of the Presentations and Publications for Attributability. 2018 NASA Human Research Program Investigators' Workshop, January 22-25, 2018, Galveston, TX (link).

Did You Know? Medical coding and astronaut health

Deborah Eudy, CPC

Physician offices and medical institutions use medical coding to assign medical information to a diagnosis or procedure code in order to standardize and report patient diagnoses and procedures, and to bill insurance companies. These codes are assigned using several systems (ICD-9 & ICD-10, CPT, and SNOMED-CT*) that have been developed by the World Health Organization, the Centers for Disease Control and Prevention, and the Centers for Medicare and Medicaid. ICD-9 and ICD-10 codes are used for diagnosis determination, CPT codes are used for procedures, and SNOMED codes were developed originally for assigning pathology terms. Today, SNOMED codes are used in diagnosis coding because they are more granular or detailed and can define information that ICD-9 and ICD-10 do not. Astronaut medical data in NASA records are assigned these codes by certified medical coders working in the LSAH group.

The databases used by LSAH capture health information about each astronaut; these data are collected from several sources, including the astronaut's outside provider records sent to the JSC Clinic, the written medical charts, and the JSC clinical electronic medical record (EMR). NASA also incorporates available health information from before an astronaut's selection, such as their military health record. Other types of health information include documentation of an astronaut's pertinent family history, past medical history, environmental exposures, symptoms and treatment, as well as the clinical data and health events obtained throughout an astronaut's career both in-flight and on the ground. This information capture continues, even after an astronaut's retirement from active duty, through participation in the annual LSAH exams.

LSAH Epidemiologists use medical coding to monitor the occupational effects of spaceflight. Medical coding reduces the overall burden on Machine Learning tools while allowing for automatic capturing of specific health events. When health events are analyzed, LSAH can identify areas of concern and allow for heightened monitoring of future health risks.

Notes:

*ICD is the International Classifications of Diseases system. Both ICD version 9 (ICD-9) and version 10(ICD-10) are used to classify diseases, signs, symptoms, abnormal findings, complaints, social circumstances, and external causes of injury or disease. [1]

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Did You Know? Medical coding and astronaut health cont.

Notes:

*CPT is the Current Procedural Terminology (used to code medical, surgical, and diagnostic services and medical procedures) [2]

*SNOMED-CT is the Systemized Nomenclature of Medicine-Clinical Terms (used to code clinical findings, symptoms, diagnoses, procedures, anatomy, organisms and other causal factors of disease, pharmaceuticals, devices and specimens) [3]

*Centers for Medicare and Medicaid [4]

References:

[1] "National Center for Health Statistics." *Centers for Disease Control and Prevention*, Centers for Disease Control and Prevention, 18 Aug. 2017, (link).

[2] "CPT® (Current Procedural Terminology)." *American Medical Association*, (link).

[3] "Overview of SNOMED CT." *U.S. National Library of Medicine*, National Institutes of Health, 14 Oct. 2016, (link).

[4] *CMS.gov Centers for Medicare & Medicaid Services*, 24 Apr. 2018, (link)

News and Notes

Coffee with CB

The Astronaut Office would like to keep you informed about office happenings, and hear what you're up to. If you are interested in meeting with some fellow astronauts over coffee or lunch while in Houston for your annual exam, please contact Karen Nyberg [redacted]. Her backup is Stephanie Wilson [redacted].

International Travel Policy

Do you live outside the United States and wish to travel to Houston for your annual LSAH physical examinations? In the past, NASA has not allowed reimbursement for international airfares. However, in some cases, and with specific NASA approval before you book, all or part of your airfare may be reimbursable.

Please call Denise Patterson at 281-244-5195 to discuss travel plans and potential reimbursement prior to booking your airfare. Thank you!

FYI

If you have a new address, phone number, or email please let us know by calling 281-244-5195 or 281-483-7999. You may also write us at:

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