



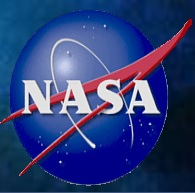
Trajectory of Research in Support of NASA's Journey to Mars

Andrea Hanson, PhD

Manager, Exercise Physiology & Countermeasures Lab

NASA Johnson Space Center

andrea.m.hanson@nasa.gov



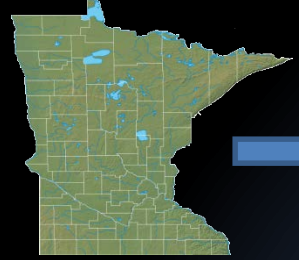
Introduction



Andrea Hanson, PhD

Professional Affiliations

- ASGSB
- AsMA
- AIAA
- ACSM
- SWE



Lake Park, MN

Grand Forks, ND



BS Chemical Engineering, 2002



Huntsville, AL



Los Angeles, CA

MS Aerospace Engineering, 2004



Boulder, CO

PhD Aerospace Engineering, 2008



Postdoctoral Fellowship, 2009



Seattle, WA

NASA JSC, 2011



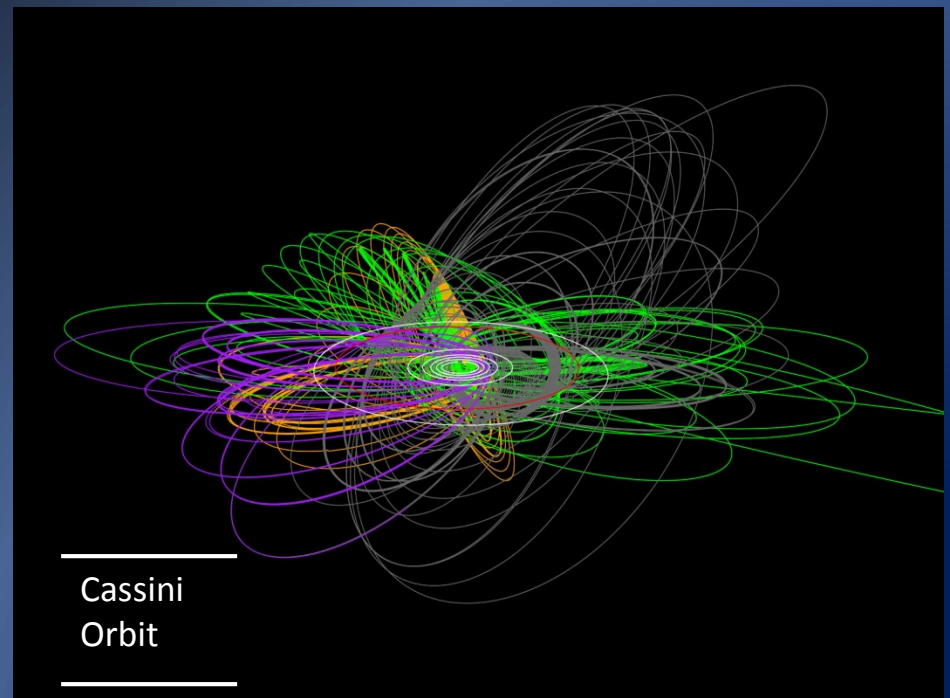
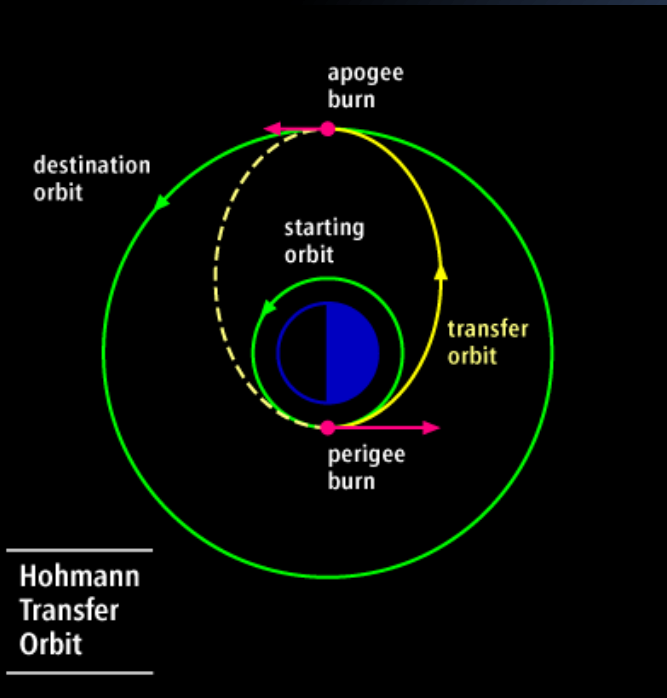
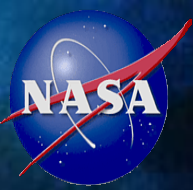
Houston, TX



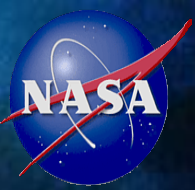
Kyoto, Japan!



Choose A trajectory

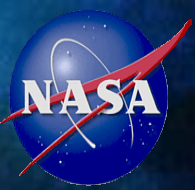


Lecture Outline

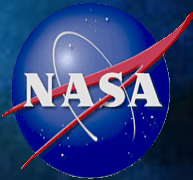


- **Introduction**
- **Physiological Adaptation to Microgravity**
- **Exercise Countermeasures**
- **Ongoing Research**
- **Spaceflight Analogs**
- **Collaboration Opportunity**

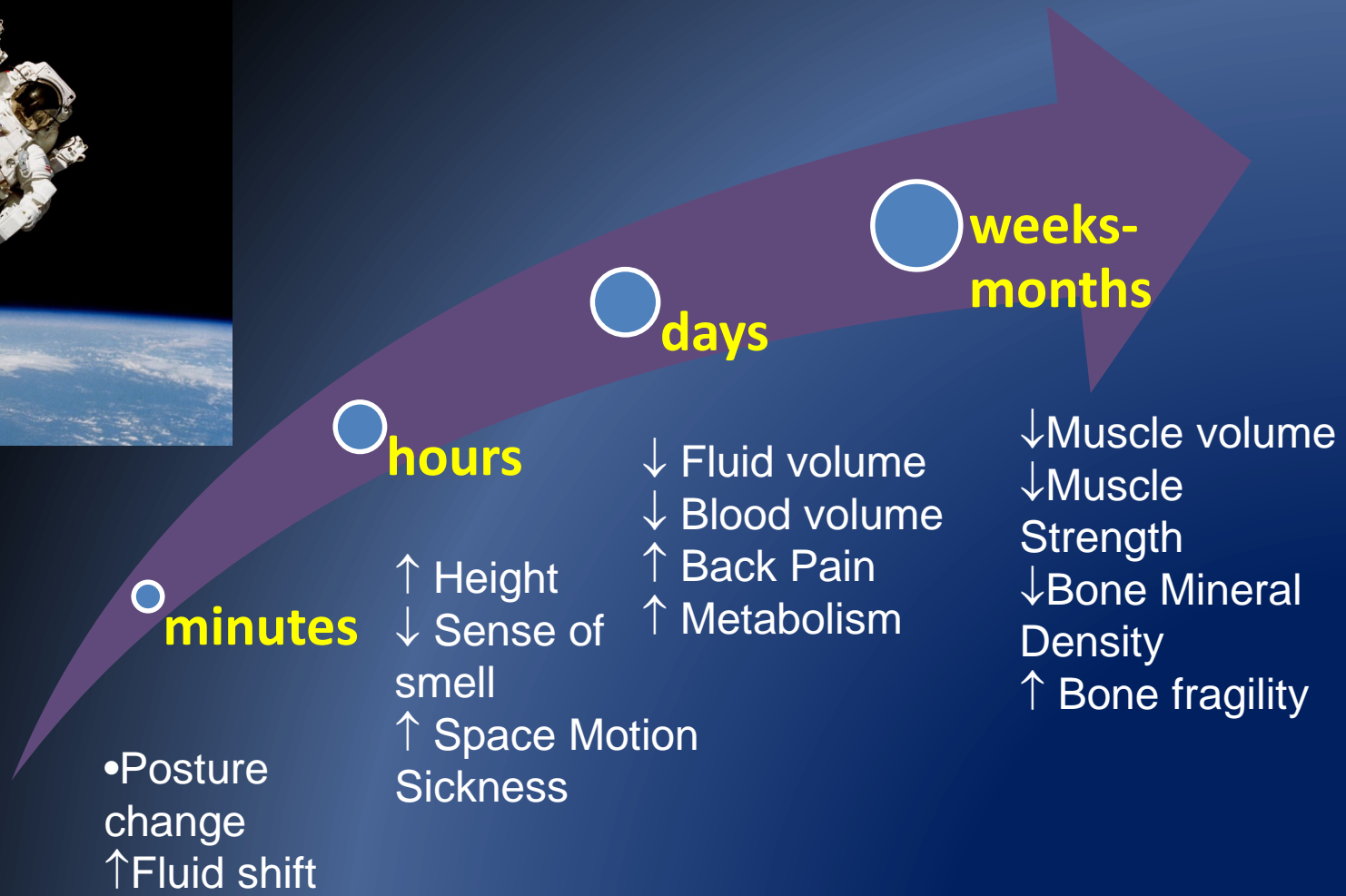
Space Vocabulary



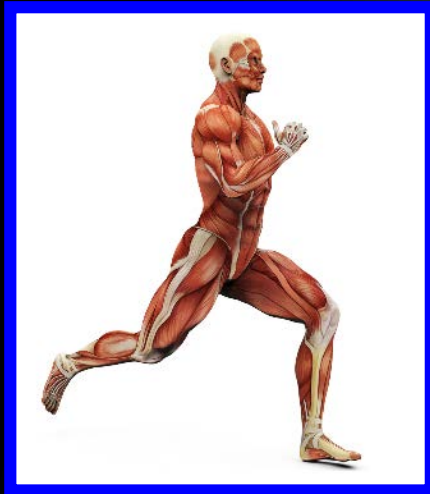
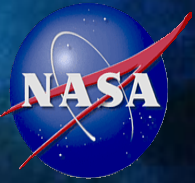
- **Analogs = Simulated environments**
- **Bioastronautics = The study and support of life in space**
- **Countermeasures = Solutions to help mitigate problems**
- **Crewmembers = Astronauts**
- **ISS = International Space Station**
- **Microgravity = Zero-G**
- **On-orbit = Orbiting the Earth**
- **STS = Space Transportation System (the Space Shuttle)**



Adaptations to Microgravity



Protect Human Physiology



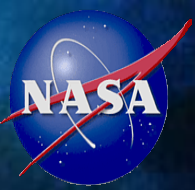
Muscle
Strength



Bone Strength
& Quality



Cardiovascular
Capacity

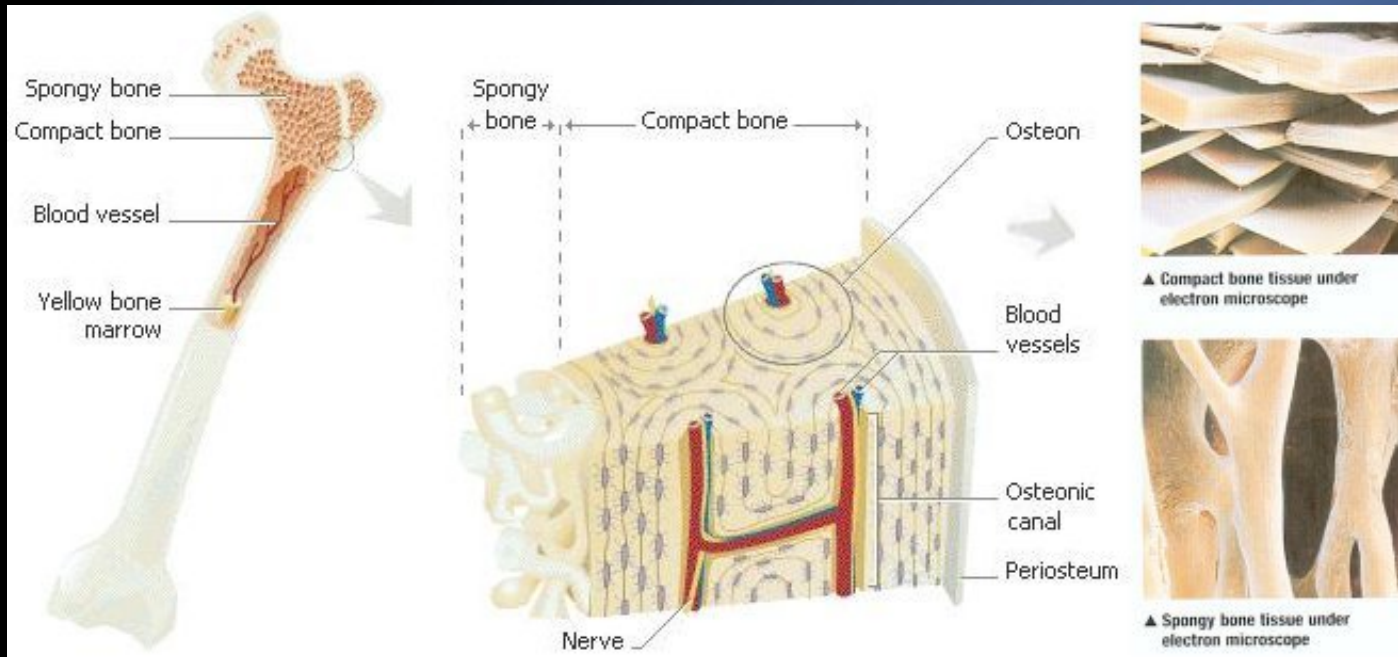
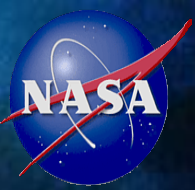


Protecting for return to Earth gravity



ISS astronauts benefit from a large support team to assist during landing activities. This welcome wagon will not be waiting on the surface of Mars.

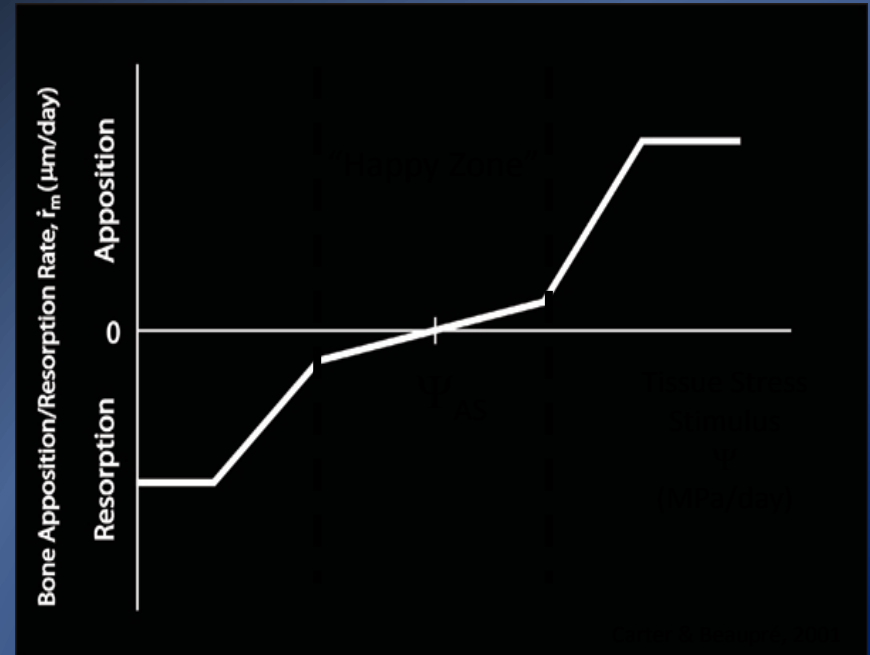
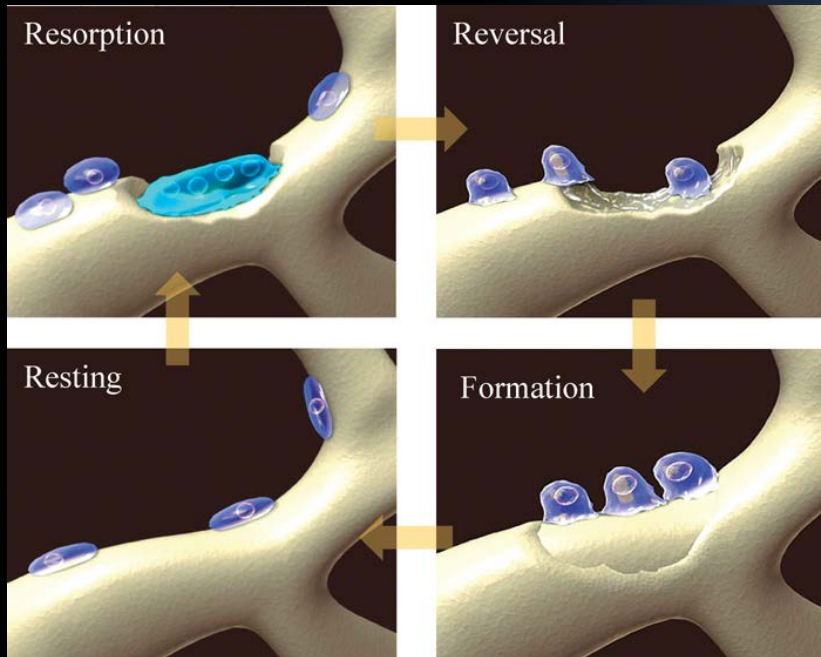
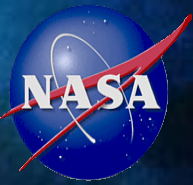
Bone Physiology



Cortical bone (compact) (80%)

Trabecular bone (Spongy) (20%)

Bone - Remodeling



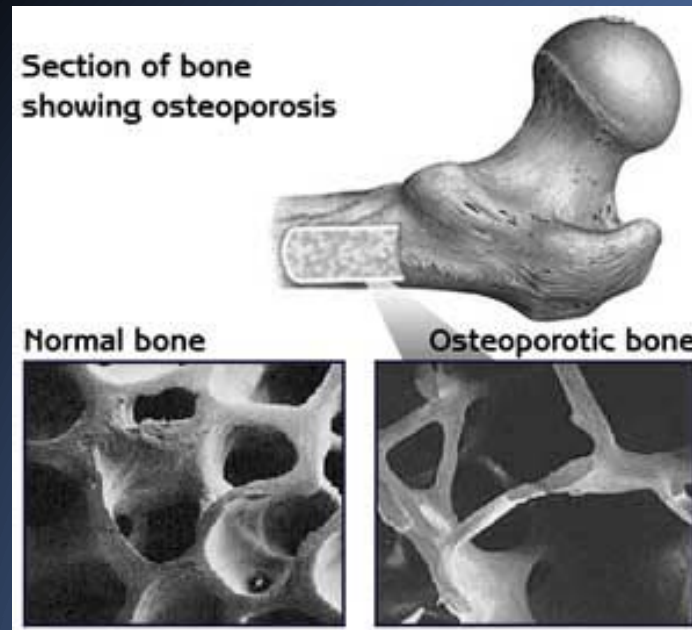
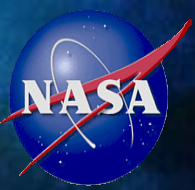
Osteoclasts

- Release enzymes
 - Dissolves bone mineral matrix
 - Dissolves collagen
- Clears away damaged bone

Osteoblasts

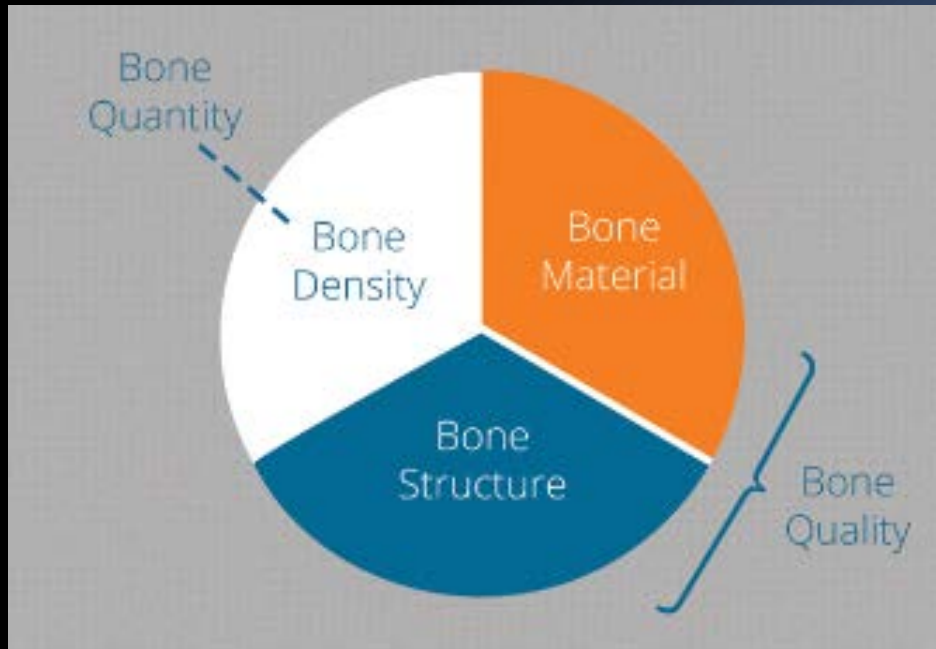
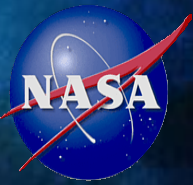
- Fill in bony cavity with bone matrix
- Releases cytokines to attract osteoclasts

Bone – Osteoporosis



Osteoporosis is a progressive bone disease that is characterized by a decrease in bone mass, density, and microarchitecture which can lead to increased risk of fracture.

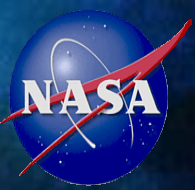
Bone Strength and Bone Quality



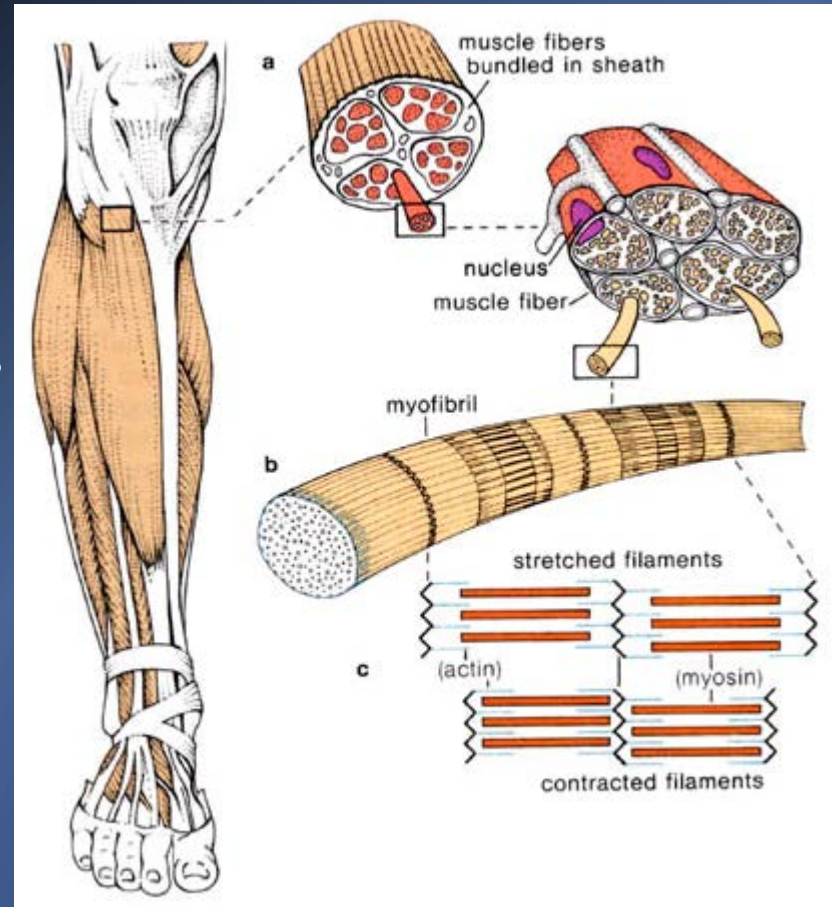
- BMD only accounts for a fraction of overall bone health.
- Overall bone quality is important to understand to best assess fracture risk
 - Geometry
 - Remodeling Rate
 - Chemical Composition
 - Microarchitecture
 - Mineralization
 - Genetic Profile

We must protect bone strength and quality in our astronauts to reduce their risk of fracture. This is particularly important for exploration missions.

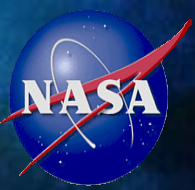
Skeletal Muscle



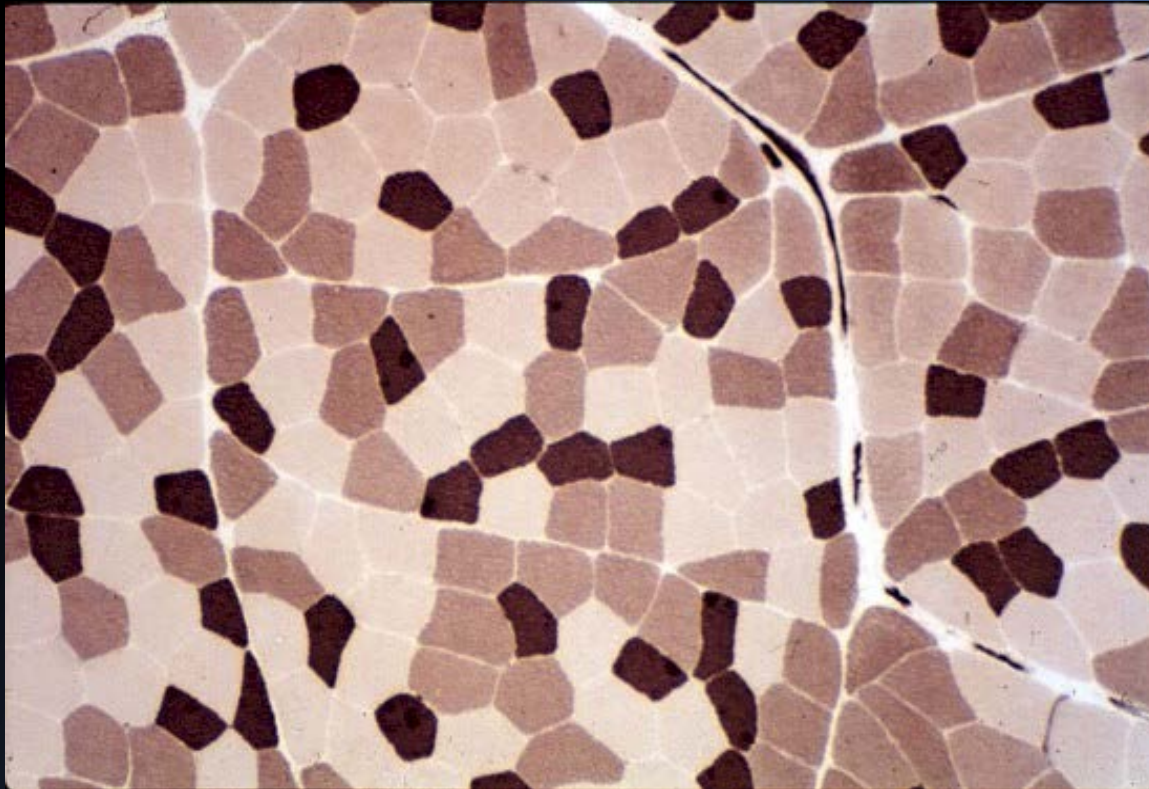
- Complex Structure
- Muscle → Myocytes
→Myofibrils → Myofilaments
- Satellite cells
- Contraction:
↑Cytosolic Ca^{+2} →
Krebs Cycle



Muscle Fiber Types



Slow (Type I) → Fast (Type II) twitch morphology during spaceflight



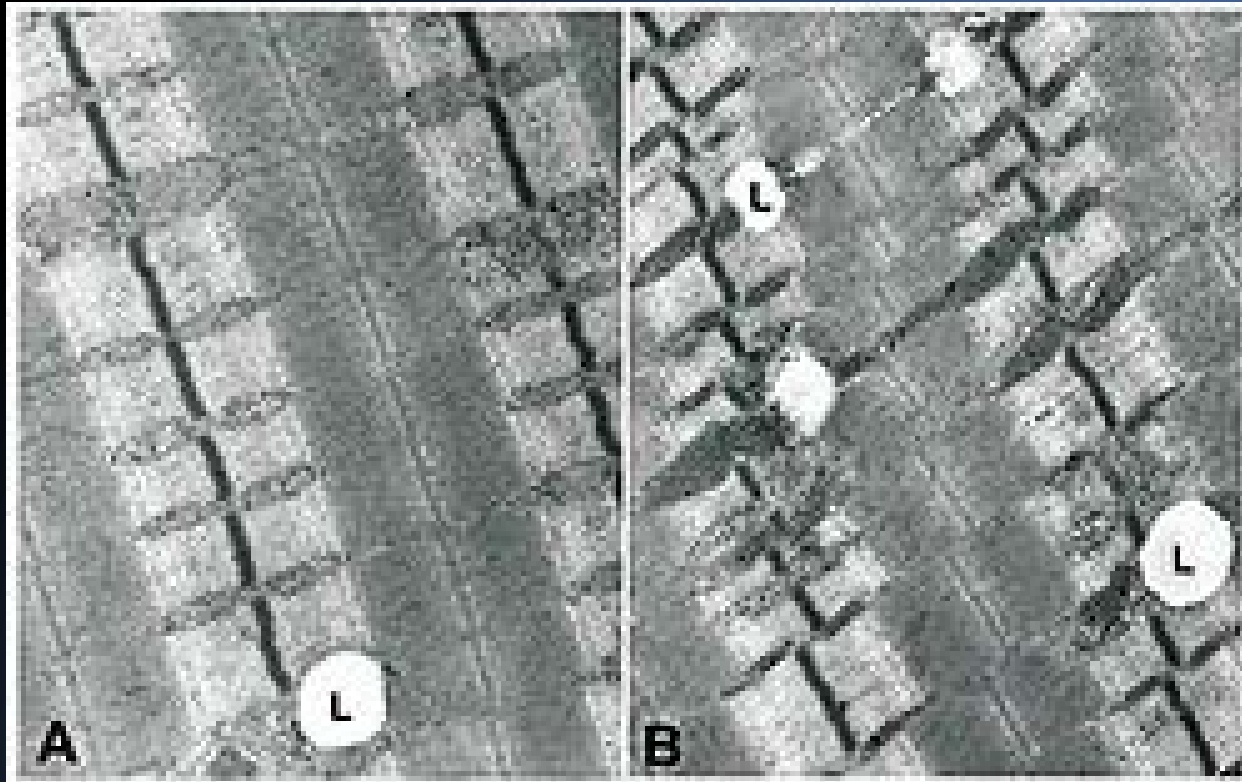
Type I
(slow oxidative)

Type IIa
(fast oxidative)

**Type IIx
(IIb)**
(fast glycolytic)

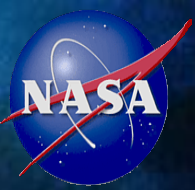
www.lionden.com/muscle-fiber-types.jpg

Z-line disruption and lipid infiltration



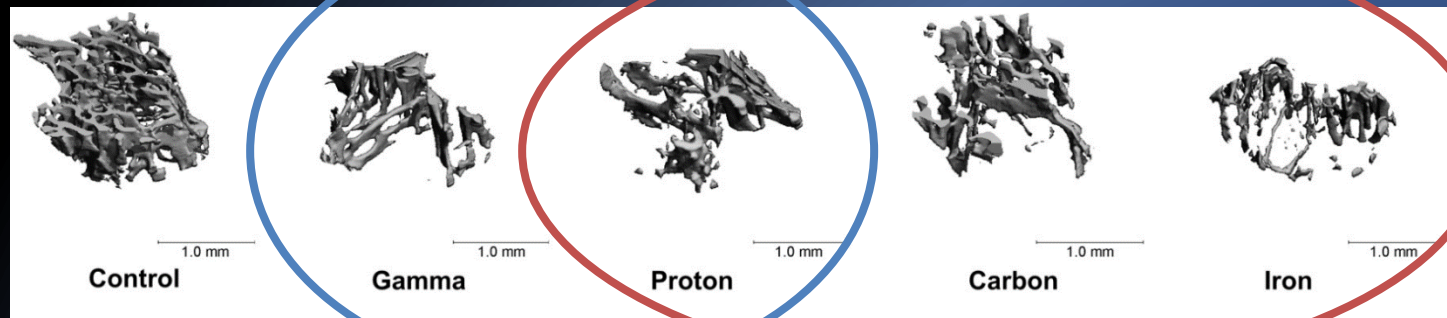
www.nasaimages.org/_/media/NAS-9-9-58603-162447

Radiation



Clinically
Relevant

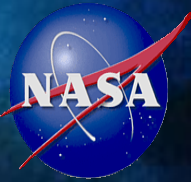
Space
Relevant



- 2-Gy dose in murine model
- 29-39% decline in trabecular volume
- 46-64% decline in trabecular connectivity
- Trip to Mars 0.5-1 Gy

Hamilton et al. *J Appl Phys*, 2006

Investigation of Myostatin Inhibition



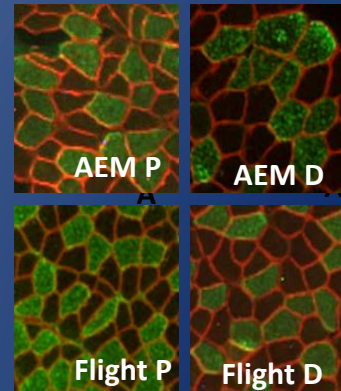
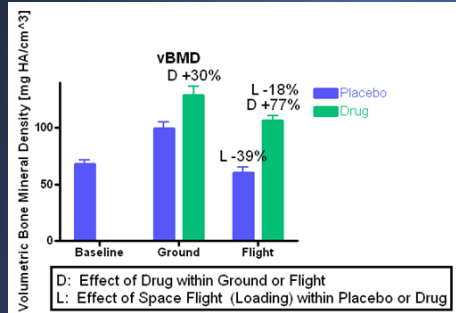
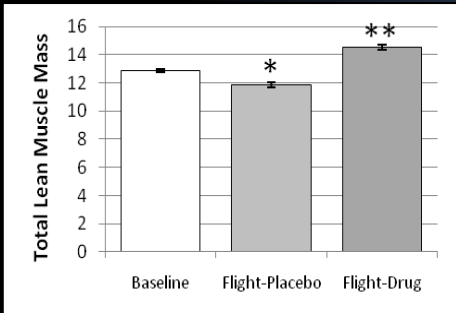
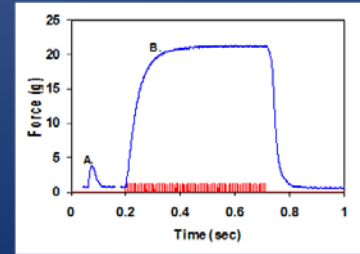
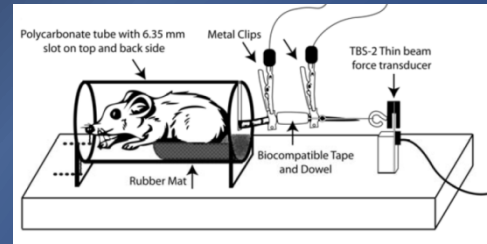
Myostatin-A powerful negative regulator of skeletal muscle mass and strength.

Selective breeding increases muscle mass in cattle



Knockout model increased muscle mass in mice

Natural mutation increased muscle mass in humans, increased performance in the Whippet (a racing dog)



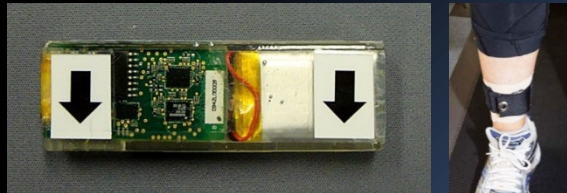


STS-118 Commercial Biomedical Test Module-02 (CBTM-02)

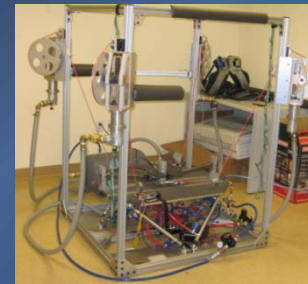


Monitoring Bone Health in Reduced Gravity Environments

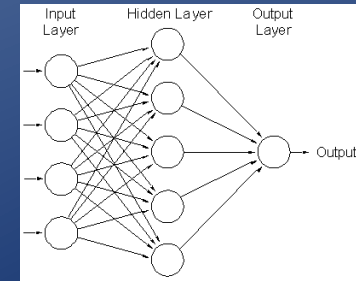
Wireless Activity Monitoring / Daily Load Stimulus



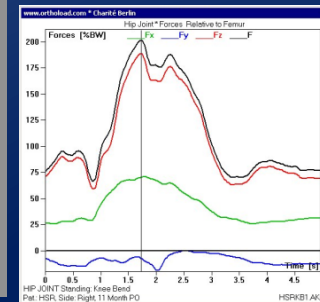
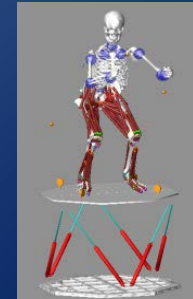
Combined Countermeasure Device (CCD)



Neural Networks / Machine Learning Algorithms

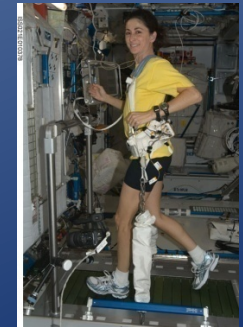
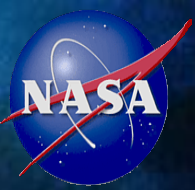


LifeModeler™ Biomechanics Simulation



JointMetrix MEDICAL

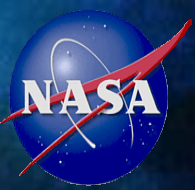
Exercise is the Foundation Upon Which all Other Spaceflight Countermeasures are Added



Apollo → ISS

- The Human Research Program is charged with identifying the optimal exercise protocol, including intensity/load and frequency of exercise, that protects crew health during exploration missions

Exercise Clearly Enhances Physiology



>20% difference
in arm volume
Left vs. Right!

- Seminal cyclic loading study by **Rubin, 1984, JBJS**
- Does increasing cycles, increase bone mass?
- Isolated avian ulna
- 0.5 Hz, 1 sec
- 0, 4, 36, 360, or 1800 cycles

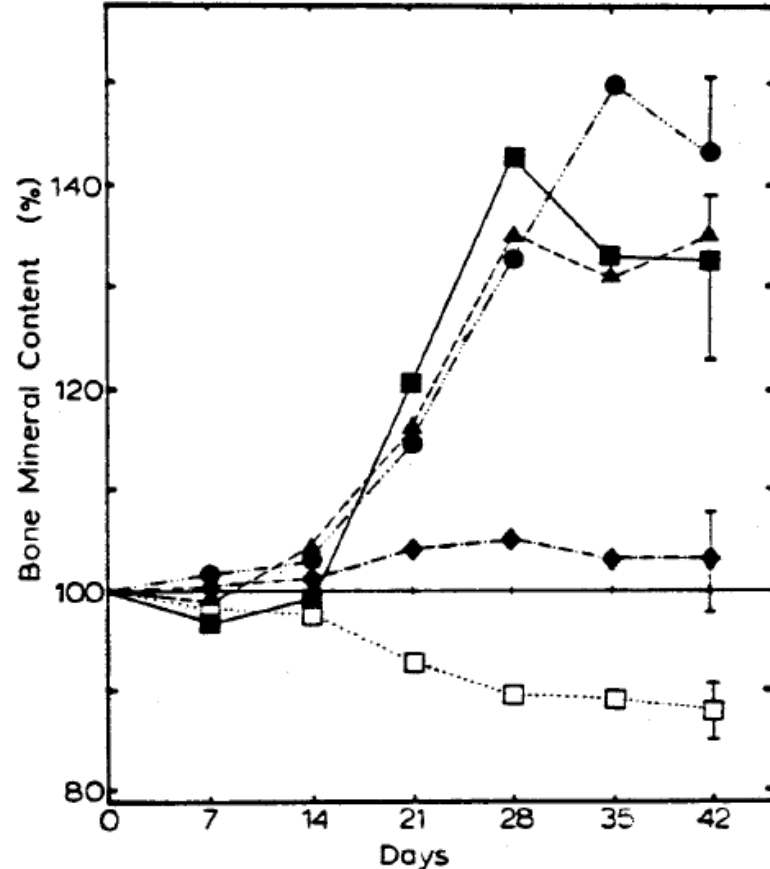
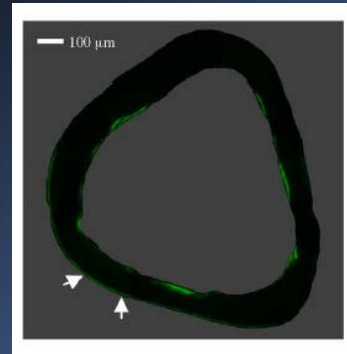
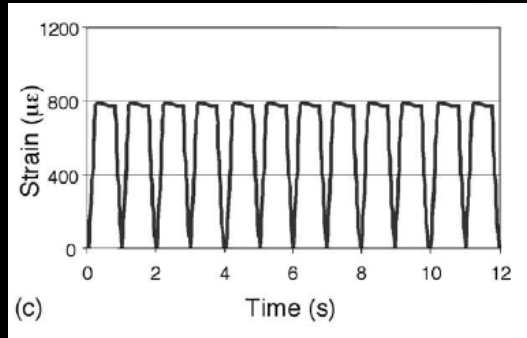
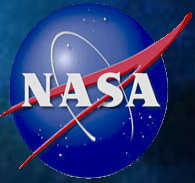


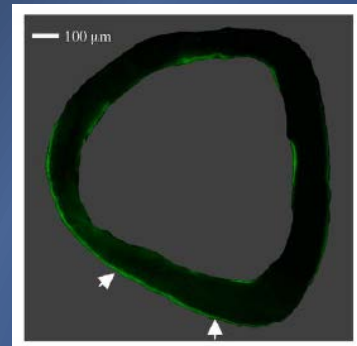
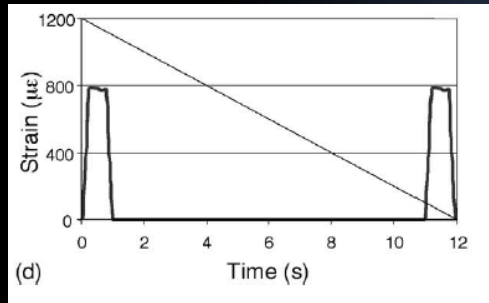
FIG. 3

Percentage change in bone-mineral content at the mid-shaft of the ulna preparation over the six-week experimental period in bones subjected to zero (□), 4 (◇), 36 (■), 360 (▲), or 1800 (●) consecutive cycles a day of an identical load regimen. The vertical lines for six-week values indicate standard deviations. The transverse scans were made using a ^{125}I source.

Can less loading be a more effective stimulus?



50 cycles/day @ 1 Hz
5 days/week for 3 weeks



50 cycles/day @ 1 Hz with
10 sec rest between cycles
5 days/week for 3 weeks

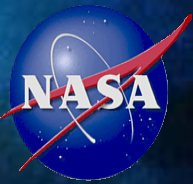
• Cyclic vs rest inserted loading

- 50 cycles/day @ 1200 $\mu\epsilon$ vs.
- 10 sec rest between 50 cycles/day @ 1200 $\mu\epsilon$

[Srinivasan et al., 2003, Bone]

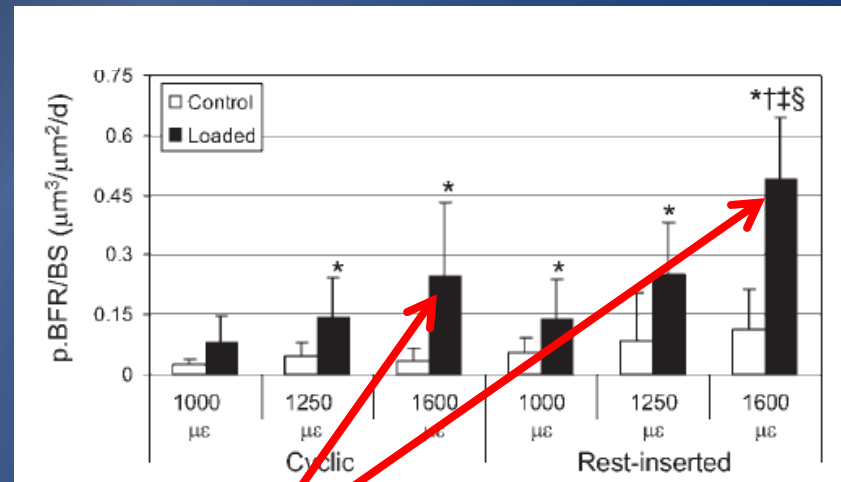
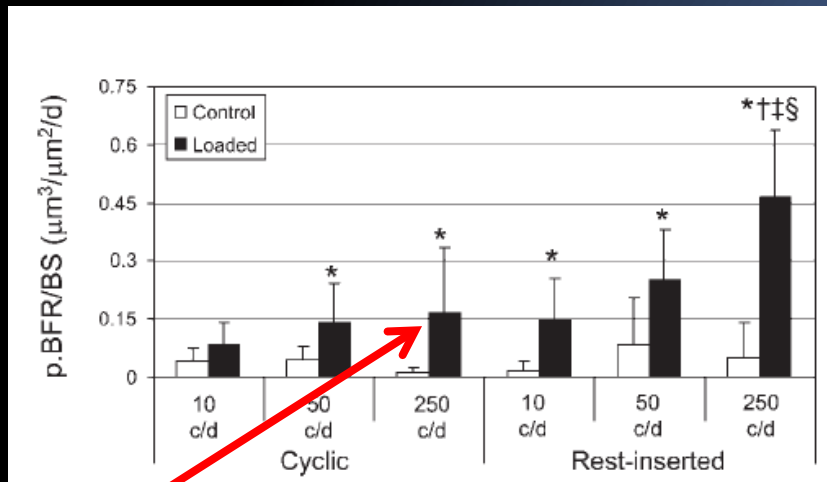
- More bone on periosteal edge with rest inserted loading!

Cyclic vs Rest - # of cycles



- Rest inserted loading (1250 $\mu\epsilon$) inhibits saturation with increased cycle number

- Rest inserted loading increases response to higher magnitude strain

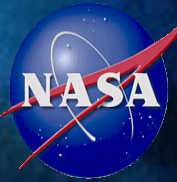


Osteogenic stimulus is saturated

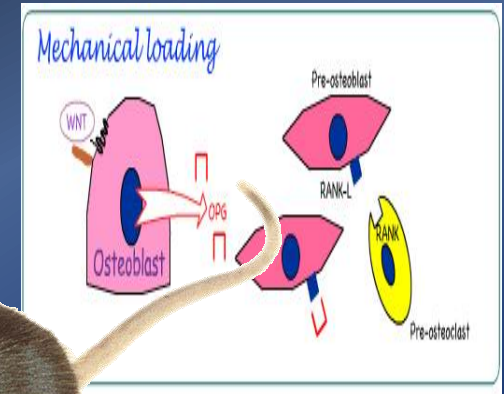
Response doubles!

Srinivasan et al., 2007, J Appl Phys.

Benefits of rest inserted exercise



- Lower magnitude
- Fewer loading cycles
- Exercise less often
- Animal studies allow rapid data turn around and exploration of cellular mechanisms
- Human studies offers clinical and operational insight
- Putting these lessons to practice:
 - Retrospective Approach: Design a robust exercise program targeting max weight training loads and HR, then sum accumulated loads.
 - Prospective Approach: Determine the number and magnitude of accumulated loads necessary to maintain fitness.



The Daily Load Stimulus

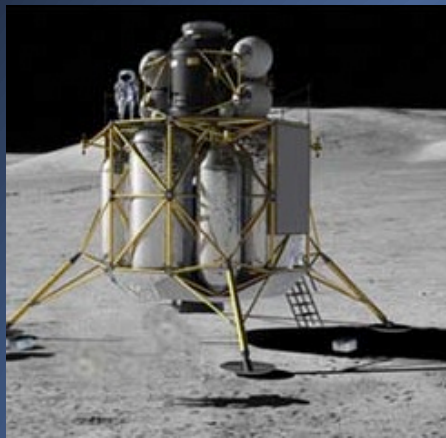
$$eDLS = \left[\sum_{j=1}^k n_j (Gz_j)^m + \frac{[AL]_{Stand}}{m} \right]^{1/2m}$$



Required Dose of Loading (Daily Loading Stimulus DLS) for Optimal Bone Health



EVA



IVA

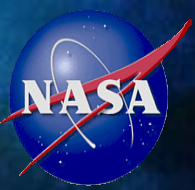


Exercise CM



Carter et al. 1987, Genc et al. 2009, Cavanagh et al. 2010

Monitoring Bone Health by Daily Load Stimulus for Lunar Missions

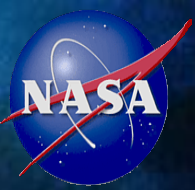


- Astronauts currently lose ~1% of proximal hip BMD per month in microgravity on the International Space Station (Lang et al., 2006)
- Will normal activity in the partial gravity environments of the Moon [1/6g] and Mars [3/8g] will be osteoprotective?

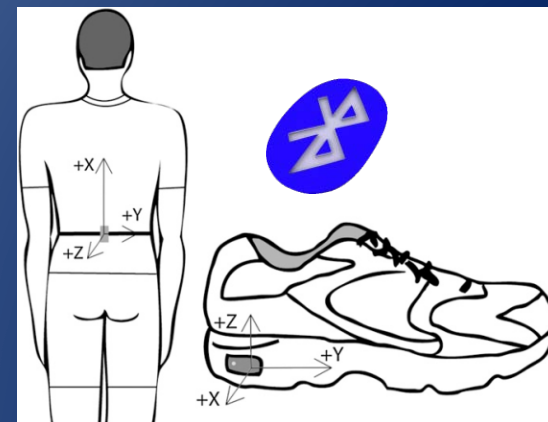
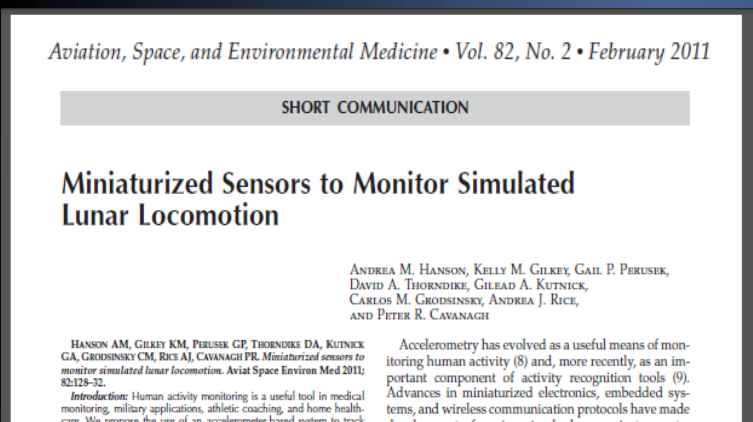
Project Goals:

- 1) To characterize gait biomechanics in reduced gravity environments in order to assess the potential contribution to BMD maintenance
- 2) To provide activity recognition during lunar and Martian missions for remote monitoring

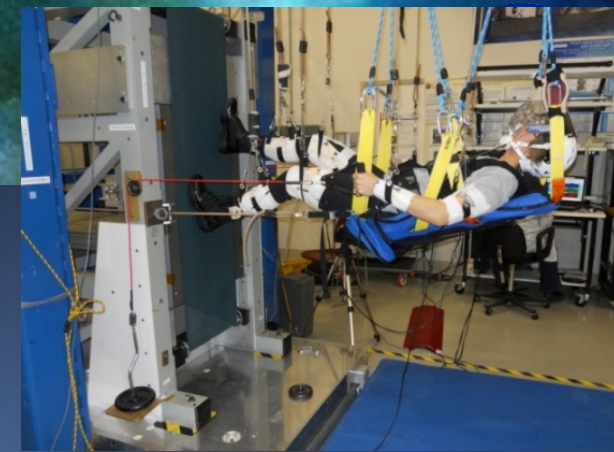
Develop accelerometer based portable activity monitoring device



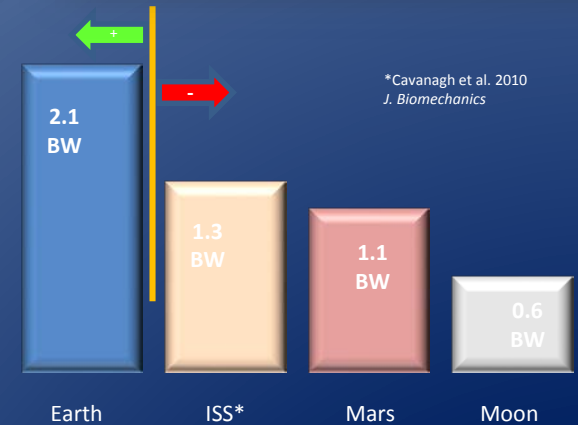
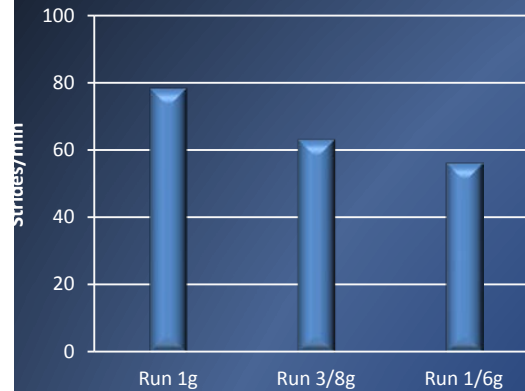
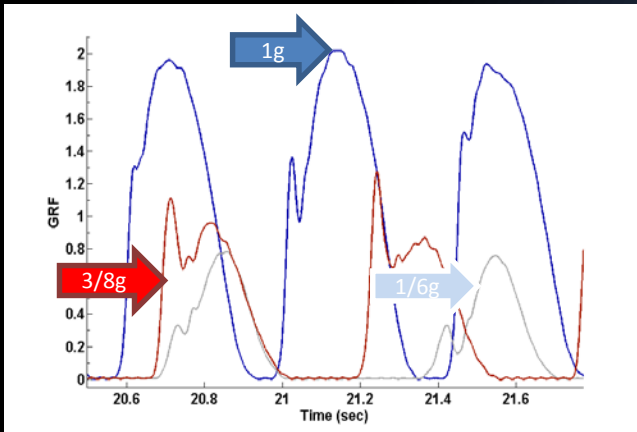
- Loading profiles (Daily Load Stimulus) are calculated from GRF which is restricted to the lab or to force measuring insoles which are cumbersome (Whalen et al. 1993, Genc et al. 2009)
- Accelerometers can be body mounted to record loading histories (Jamsa et al. 2004)
- Acceleration data is also useful for activity recognition (Baek et al. 2004, Sharma et al. 2008)
- Approach: Develop a library of GRF during mission relevant activity and exercise -> use accelerometer for activity recognition in reduced gravity environments -> use a look up table to match GRF to activity -> sum accumulated loads -> test in the field



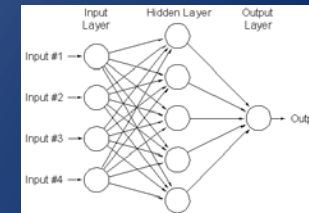
GRFs at 1G, 3/8G, and 1/6G



- Strides are longer in reduced gravity
- Step frequency decreases with decreased gravity
- Peak GRFs decrease during running

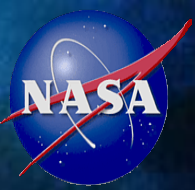


- Accelerometers useful to describe gait characteristics (stride length and step counts).
- More useful as input to neural networks for activity recognition algorithms.
- Partial gravity environments are not likely to be osteoprotective on their own.



Achieved 100% recognition Lunar Walk, Lope, Run, Hop

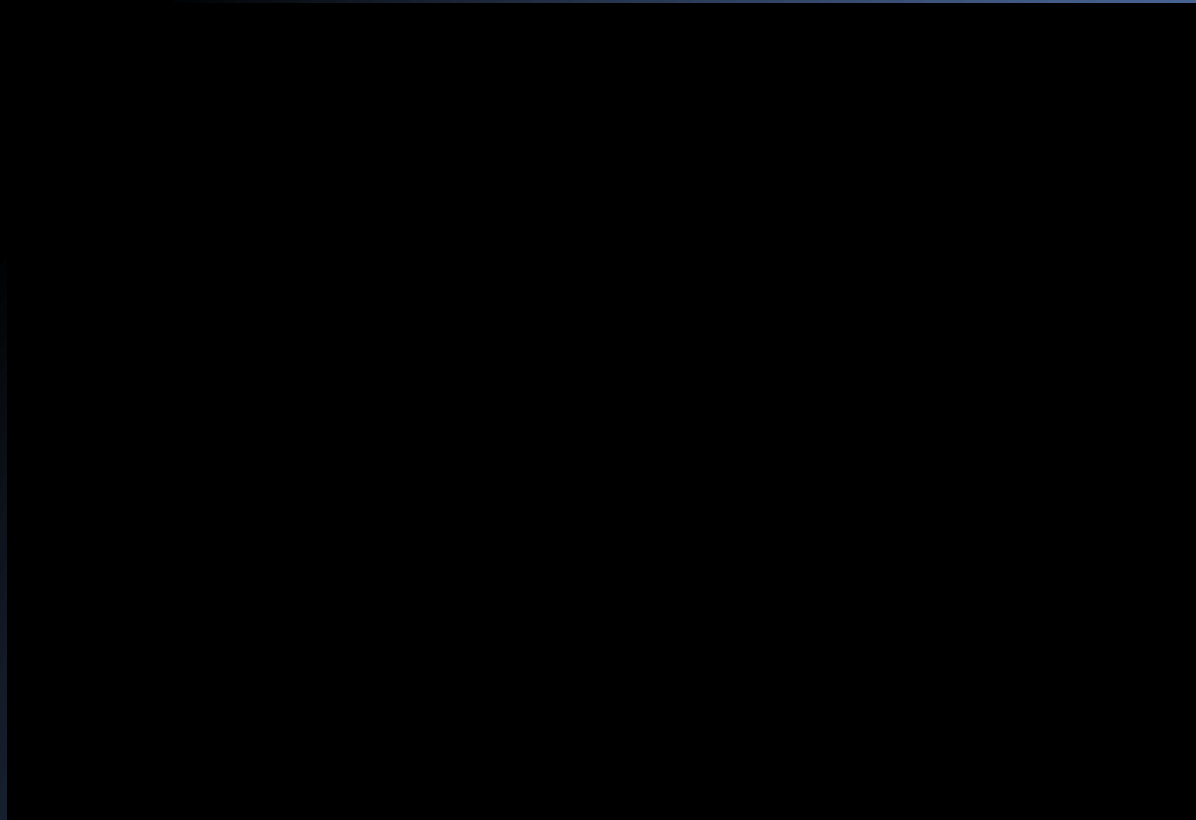
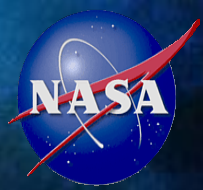
All Confusion Matrix					
Output Class	1	2	3	4	
1	15 24.2%	0 0.0%	0 0.0%	0 0.0%	100% 0.0%
2	0 0.0%	16 25.8%	0 0.0%	0 0.0%	100% 0.0%
3	0 0.0%	0 0.0%	16 25.8%	0 0.0%	100% 0.0%
4	0 0.0%	0 0.0%	0 0.0%	15 24.2%	100% 0.0%
	100% 0.0%	100% 0.0%	100% 0.0%	100% 0.0%	100% 0.0%
	1	2	3	4	Target Class



Exercise Countermeasures

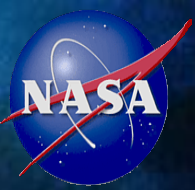
We've come a long ways since Skylab...

Skylab 1973-74 (de-orbit 1979)



Science meets Engineering: Couple our knowledge of bone mechanobiology with exercise hardware and Rx design to optimize crew health.

Exercise Countermeasures on ISS



Astronauts are scheduled to exercise 2.5 hours 6 days a week!



Cycle Ergometer with Vibration
Isolation System
(CEVIS)

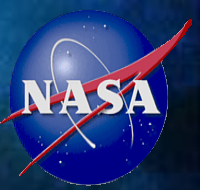


Advanced Resistive Exercise
Device
(ARED)



Second Generation Treadmill
C.O.L.B.E.R.T.
(T2)

How much time should we spend on exercise?



Hickson et al., (1981, 1982, 1985) try to preserve VO₂ max



- Duration

- Reduced from 40 to 26 or 13 min/day



- Frequency

- Reduced from 6 to 4 or 2 days/week



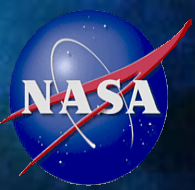
- Intensity

- Work rate reduced by 1/3 or 2/3

- To minimize time spent on exercise, exercise frequency and duration may be reduced but intensity must be as high as reasonably possible.

- Can we meet aerobic training needs and protect bone?

Recommendations on physical activity levels from the AHA and ACSM



The American Heart Association Recommendations for Physical Activity in Adults

At least **30** minutes of moderate-intensity aerobic activity **At least 5** days per week for a total of **150** minutes



OR

At least **25** minutes of vigorous aerobic activity **At least 3** days per week for a total of **75** minutes



or a combination of the two

AND

Moderate to **HIGH INTENSITY** muscle-strengthening activity **At least 2** days per week for additional health benefits



© 2013

Learn more at heart.org/ActivityRecommendations.



Add years to your life one step at a time.

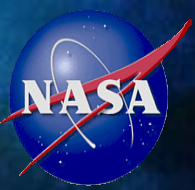
Physical inactivity is the leading cause of death in the United States. Just 150 minutes of exercise a week reduces your risk of death by treating and preventing heart disease, high blood pressure, diabetes, stroke and more.

Learn more about the health benefits of exercise at www.ExerciseisMedicine.org.



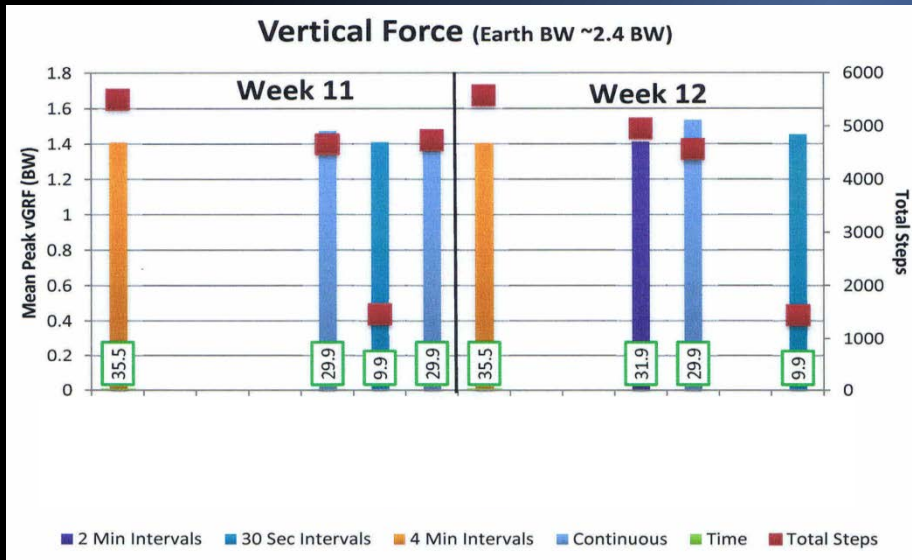
Exercise is Medicine is a multi-organizational initiative, coordinated by the American College of Sports Medicine. Support for the program is provided in part by the Merck Foundation.

How do ACSM / AHA recommendations compare to ISS exercise?

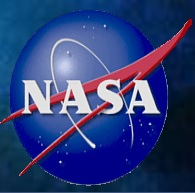


	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
ARED	35-60 min	35-60 min	35-60 min	35-60 min	35-60 min	35-60 min	
T2	30 min	30 min		30 min	30 min		
CEVIS			30 min			30 min	

- Recommended: 2 days of strength training and 150 min of moderate aerobic exercise per week
- 6 days muscle strengthening
- ~180 minutes aerobic activity



- ~10,000 steps per day are recommended
- 5-6K steps per day, 4 days a week are acquired



NASA Future Directions

HRP Risk Mitigation Maturation Plan

~2035–20nn

Fine-tune mitigation approaches

- Exploration vehicles
- Planetary surfaces

~2021–2030

Validate mitigation approaches

- Orion
- Deep-space hab
- Lunar surface (?)

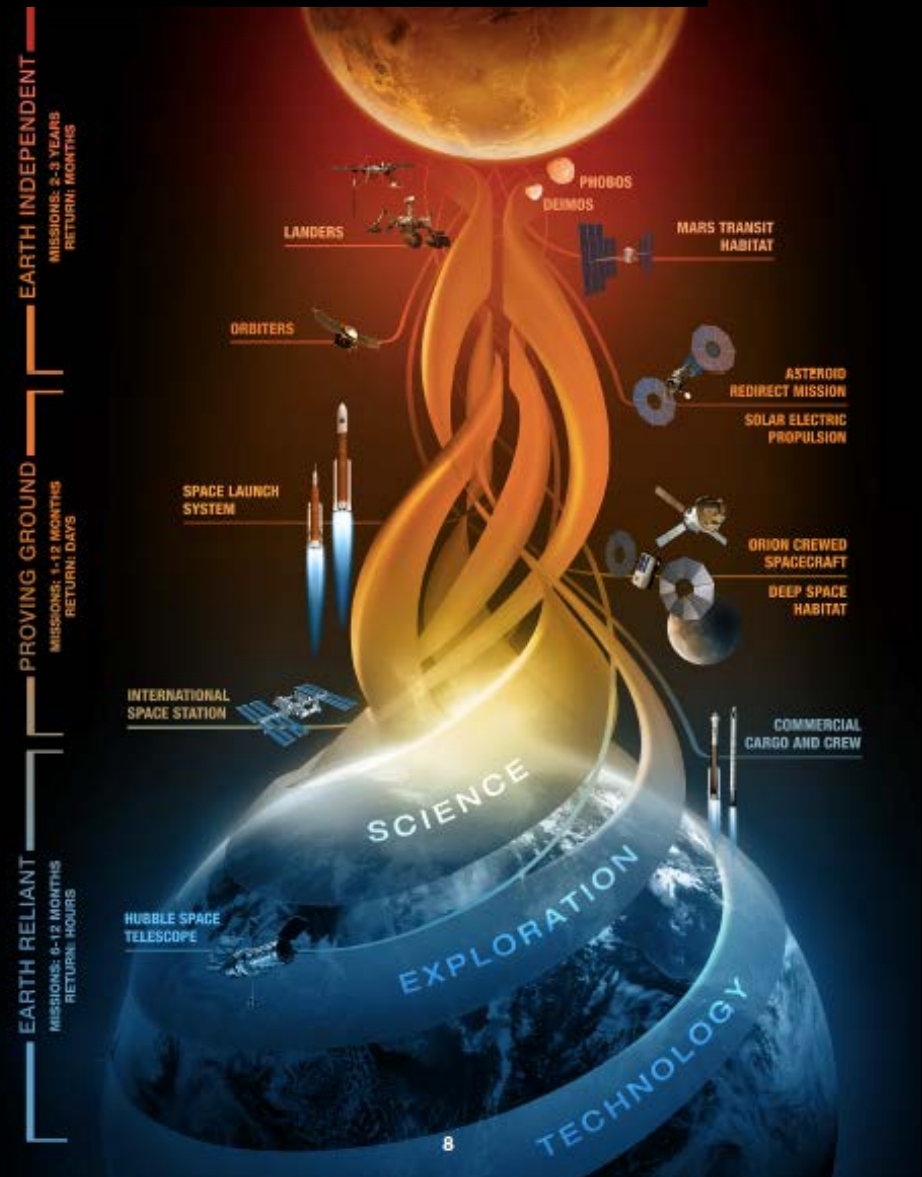
Inform exploration system designs

Now–2024 (+/-)

Develop/test mitigation approaches

- ISS
- Spaceflight analogs
- Ground-based laboratories

Inform deep-space hab designs



To the Moon, Mars & Beyond!

International Space Station



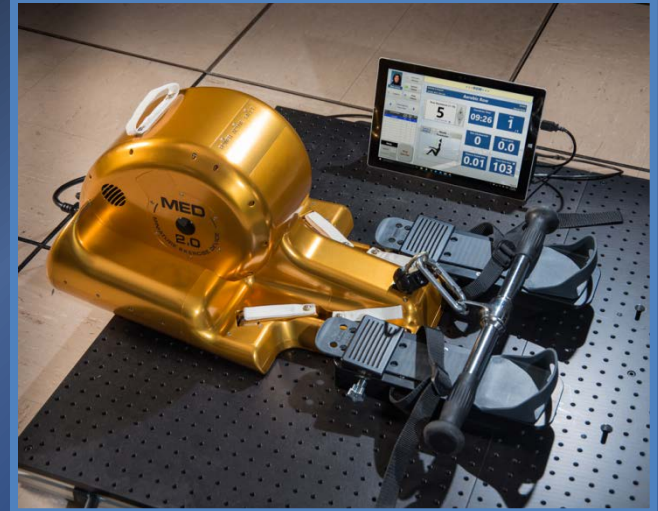
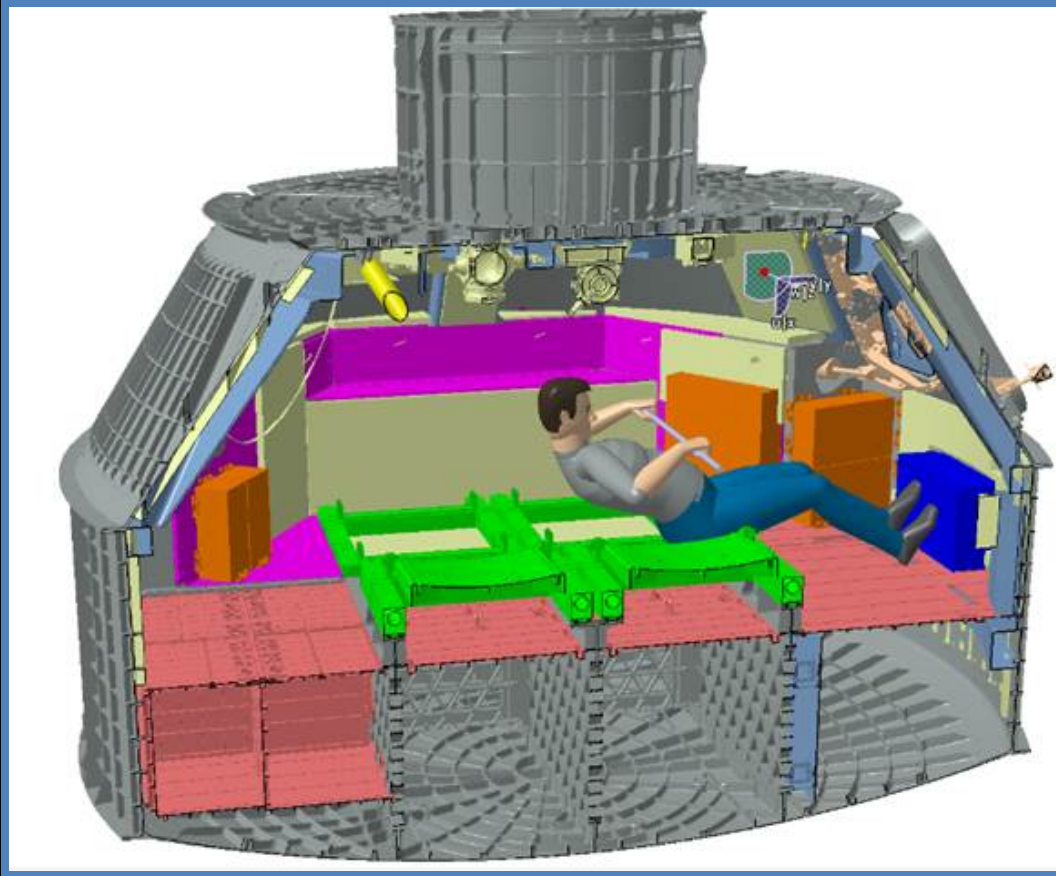
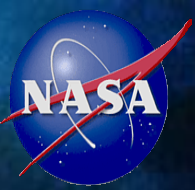
Habitable Volume: 15,000 Ft³

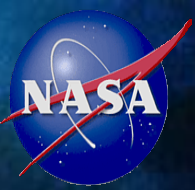
Orion Capsule



Habitable Volume:
316 Ft³

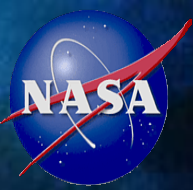
Preparing for Exploration beyond ISS





On-Going Research

In-Flight Research



SPRINT

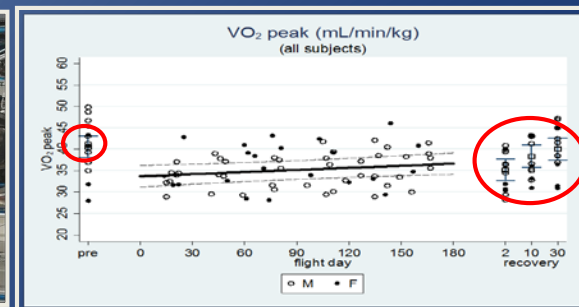
Evaluate muscle, cardiovascular fitness, and bone health following a new **higher intensity**, lower duration and frequency exercise prescription during spaceflight.

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Resistance	35-60 min		35-60 min		35-60 min		
Aerobic Interval		32 min		15 min		35 min	
Aerobic Continuous	30 min		30 min		30 min		

VO₂ Max

Measured VO₂max and cardiac output using the PPFs pre-, in-, and post-flight.

- Early onset decreases in VO₂max
- Begin cardiovascular exercise early in mission
- Recommend revision of medical requirement for inflight assessment

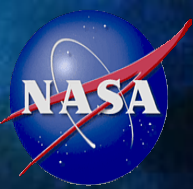


ARED Kinematics

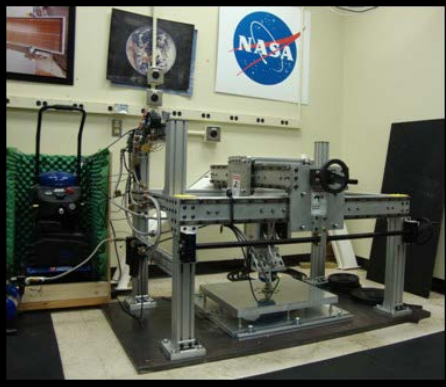
Analysis of human movement, muscle activation and joint torques generated during ARED exercise. Joint project between NASA and the Italian Space Agency



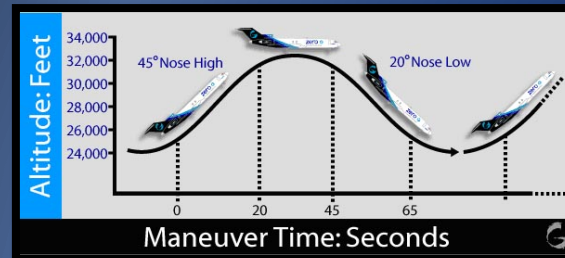
Exercise Hardware & Performance Monitoring



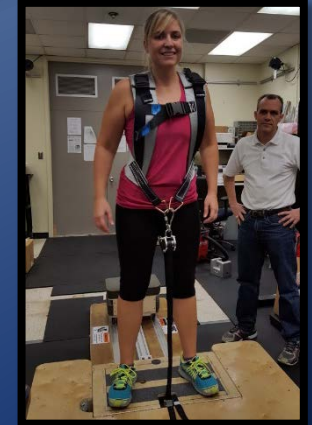
Hardware Redesign



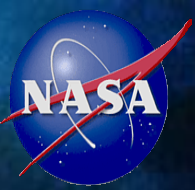
Portable load monitoring technologies



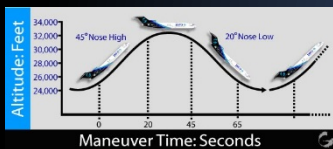
New Exercise Hardware Evaluation



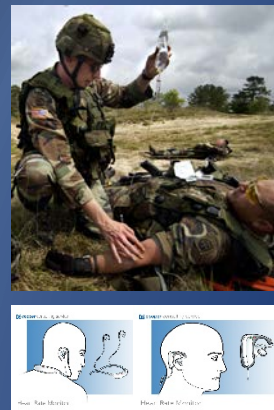
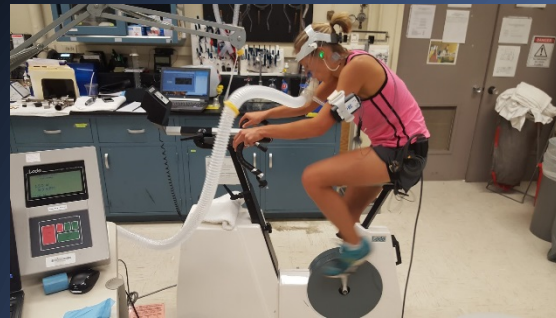
Partnerships with Academia, Industry, & Government Agencies



Load Monitoring Technology & Advanced Exercise Hardware

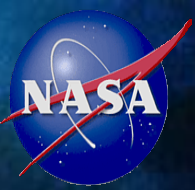


Commercial Development of Mini Earbud Based Biosensor



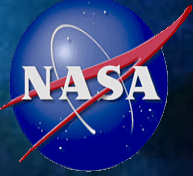
Wearable Biosensors & Human Exploration Research Analog



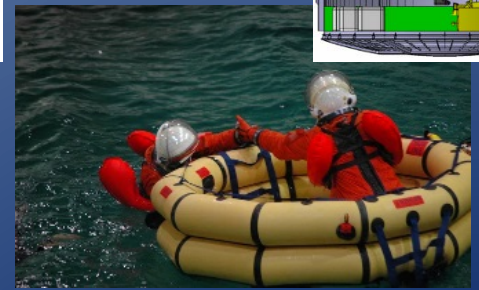
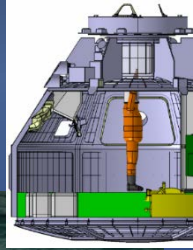
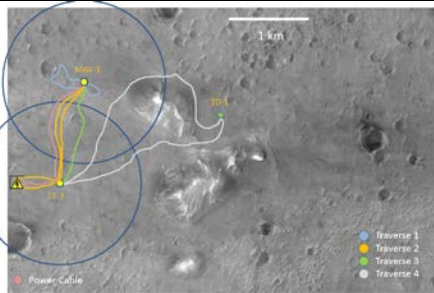


Spaceflight Analogs

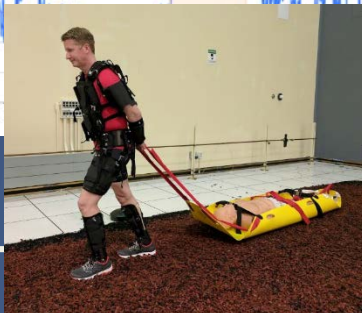
Fitness for Mission Tasks Study



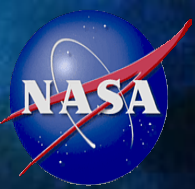
1. Ambulate 1.5 km and equipment deployment
2. Hill climb (1 km ascent and 1 km descent) and equipment deployment
3. Incapacitated crewmember rescue
4. Top hatch vehicle egress



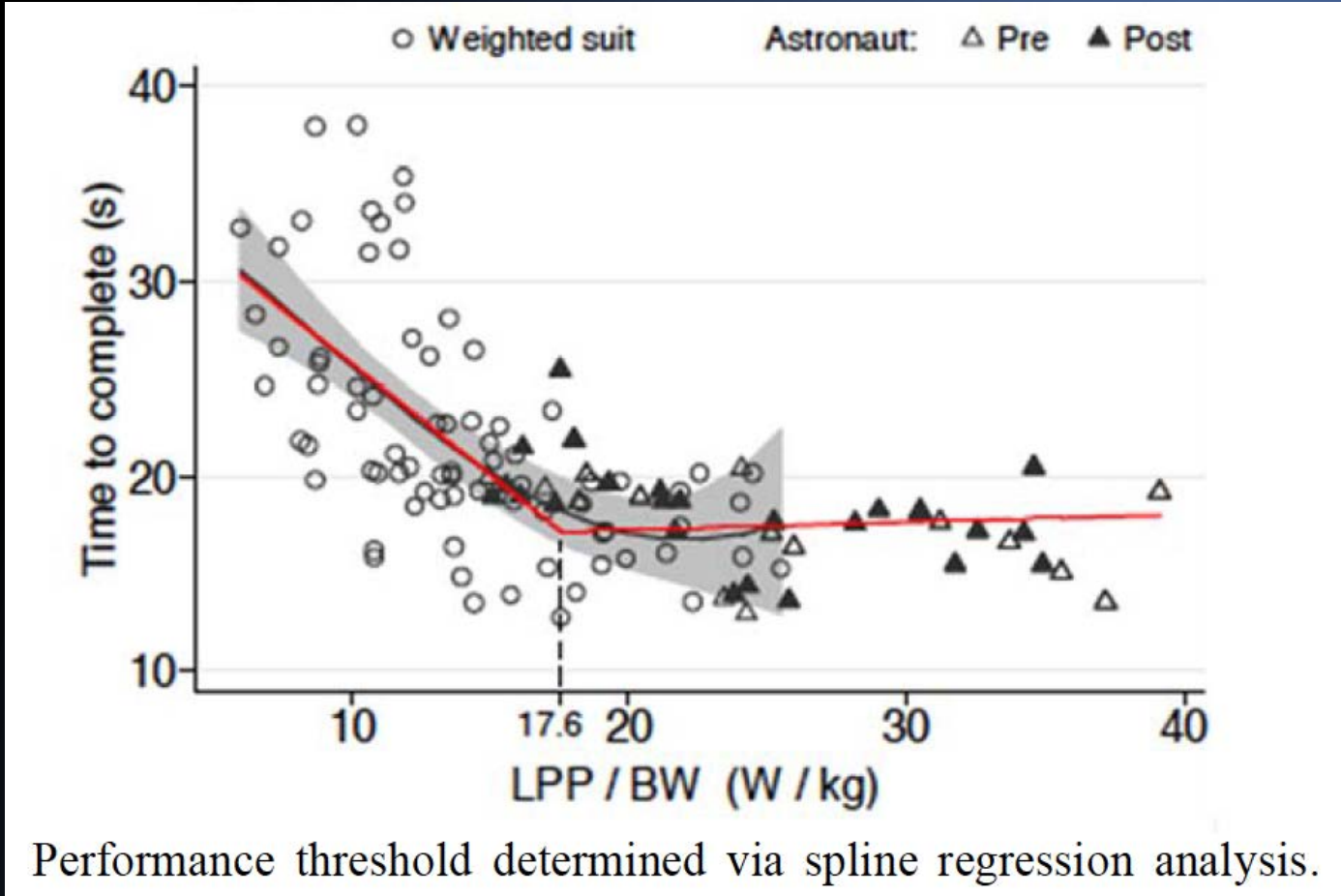
➤ Exercise Physiology and Countermeasures Team is working with the Orion Crew Survival Engineering group to conduct emergency vehicle egress exercises in the NBL and Gulf of Mexico; this field data will be correlated with the laboratory-based mission tasks testing.



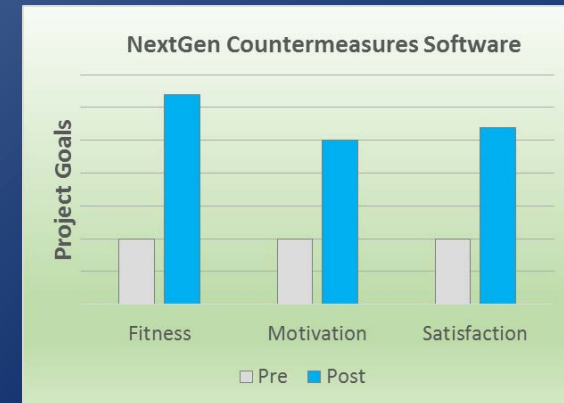
FMT Study Proposal Performance Results



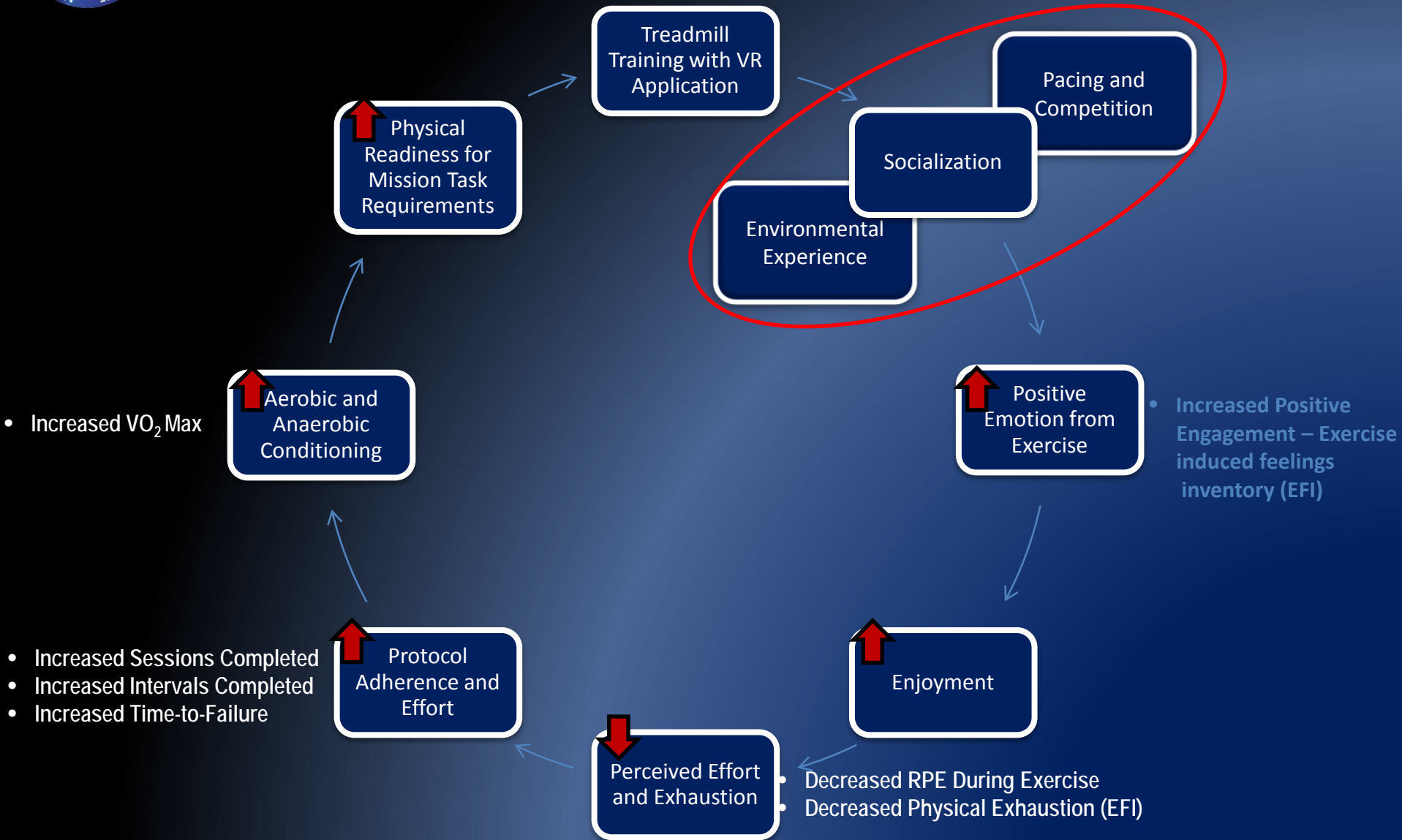
- The FMT Study data will yield performance curves and thresholds such as the plot shown below:



- **NSBRI funded research grant to develop the 'NextGen' exercise software.**
 - Develop a software architecture to integrate instructional, motivational and socialization techniques into a common portal to enhance exercise countermeasures in remote environments.
 - Increase user efficiency and satisfaction, and institute commonality across multiple exercise systems.
 - Utilized GUI design principals focused on intuitive ease of use to minimize training time and realize early user efficiency.
 - Project requirement to test the software in an analog environment.
- **Top Level Project Aims**
 - 1) Improve the usability of crew interface software to exercise CMS through common app-like interfaces.
 - 2) Introduce virtual instructional motion training.
 - 3) Use virtual environment to provide remote socialization with family and friends, improve exercise technique, adherence, motivation and ultimately performance outcomes.



Logic Model for Hypothesis



Enhance the Capabilities of In-Flight Exercise Software



One Interface

Exercise History

Help Videos

Logout

Prescription Exercises

#	Exercise Name	Load	Reps	Sets
1	Deadlift	50	10	3
2	Aerobic Row	5	5	4

Mode: Manual Prescriptions

Stop Exercise

Calculating Thresholds, do a few full repetitions ...

Threshold Calibration

18 Jan 2017 13:06:38

Deadlift

Resistive

Current Load

0

Repetitions

0

/ 10

Sets

0

/ 3

Elapsed Time

01:35

Heart Rate

0

Form Type:

- Good deadlift!
- Bar moved around the knees
- Extended back
- Hips rose first
- Rounded back
- Shoulders were behind bar

Step 1: Load model pose. Labeled Model Name: m16a2

Step 2: Show the start pose and drag 'starting model' (default) STATE COORDINATE

Step 3: Create a file name. File name: 0666

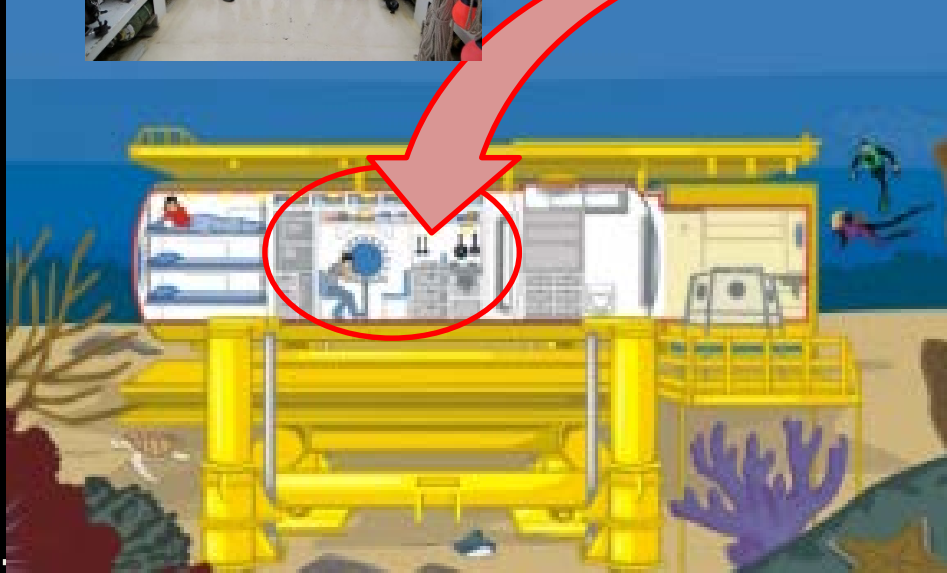
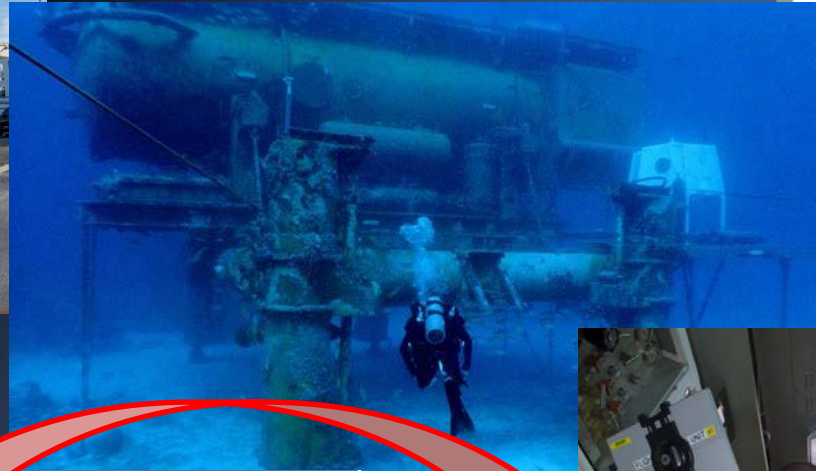
STOP RECORDING

Page 3

Page 51

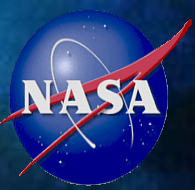
Aquarius Reef Base

Aquarius is located ~9 miles south of Key Largo, FL at ~60 feet deep.





System Usability Assessment



Morae® Analysis (~20 hours of video)

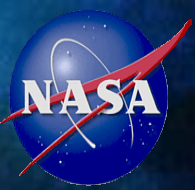
- Allows you to record and remotely observe user interactions (navigation through software screen only) and audio recording for analysis of in-session commentary.

Key Feedback Captured

- **Connectivity issues** sometimes resulted in failure to transfer exerciser protocols, pop-up of post-session survey, and transfer of data files.
- Revealed the **exercise demonstration videos** were in a bad location.
- It was not clear how to **navigate through the Rx list**.
- The Bluetooth **Heart Rate Monitor was difficult to pair**.
- **Server issues** disrupted synchronization of data files.
- Exercise **threshold settings** need higher tolerance to capture all repetitions performed.
- Great **crew-to-crew training** and shared experience.
- Get rid of need to **select start/stop** at each new set.

- *“This is a pretty legit workout!”*
- *“You have to hit end/start exercise every time and I found that very annoying.”*
- *“That doesn’t seem to work.” (paired with screen interaction provided flag on specific issue-selecting exercise in list vs using navigation arrows)*

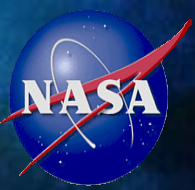
Artificial Gravity (AG) Potential Benefits



- Better to prevent issues rather than to apply countermeasures after the fact.
- AG produces multi-system effects.
- AG is a potential countermeasure for VIIP (Visual Impairment Intracranial Pressure) syndrome.
- AG reduces countermeasure requirements after landing on planetary surface.
- Rehabilitation starts 6 months earlier than a non-AG mission, and is complete when crew returns to Earth.



NASA HRP – Human Risks of Spaceflight



Grouped by Hazards – 30 Risks & 2 Concerns

Altered Gravity Level

- Vision alterations
- Renal stone formation
- Sensorimotor alterations
- Bone fracture
- Impaired performance
- Reduced aerobic capacity
- Adverse host-microorganism interactions
- Urinary retention
- Orthostatic intolerance
- Back pain
- Cardiac rhythm problems
- *Effects of medication*
- *Intervertebral disk damage*

Radiation

- Exposure to space radiation

Distance from Earth

- Limited in-flight medical capabilities
- Toxic medications

Isolation

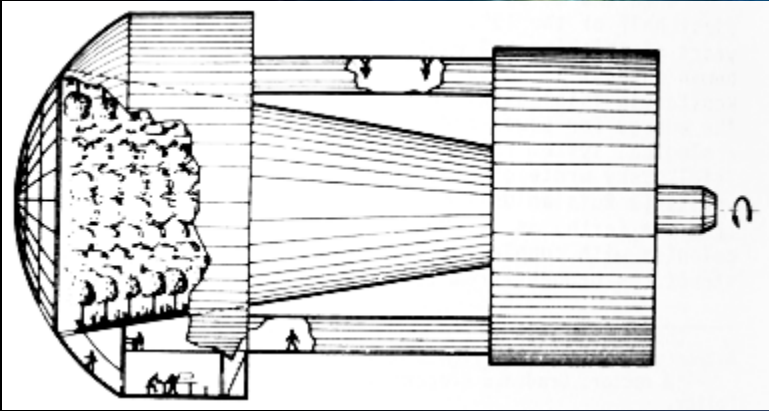
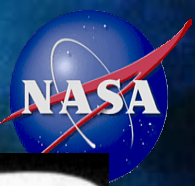
- Adverse cognitive or behavioral conditions
- Performance & behavioral health decrements

Hostile/Closed Environment– Spacecraft Design

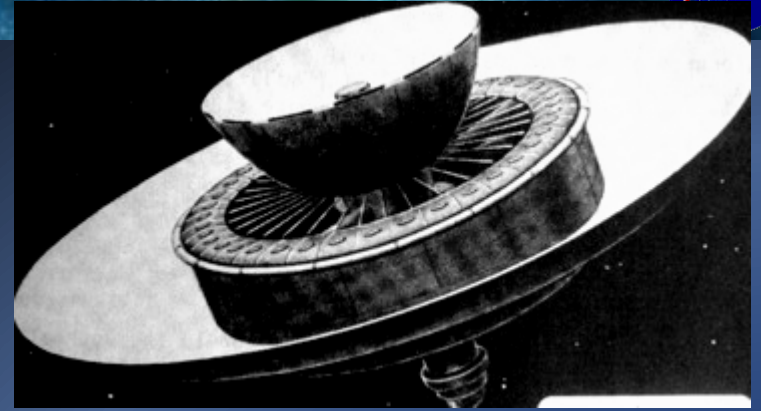
- CO2 exposure
- Inadequate food/nutrition
- Inadequate human-system interaction design
- Injury from dynamic loads
- Injury during EVA
- Celestial dust exposure
- Altered immune response
- Hypobaric hypoxia
- Sleep loss & work overload
- Decompression sickness
- Toxic exposure
- Hearing loss
- Sunlight exposure

Risks potentially minimized by artificial gravity

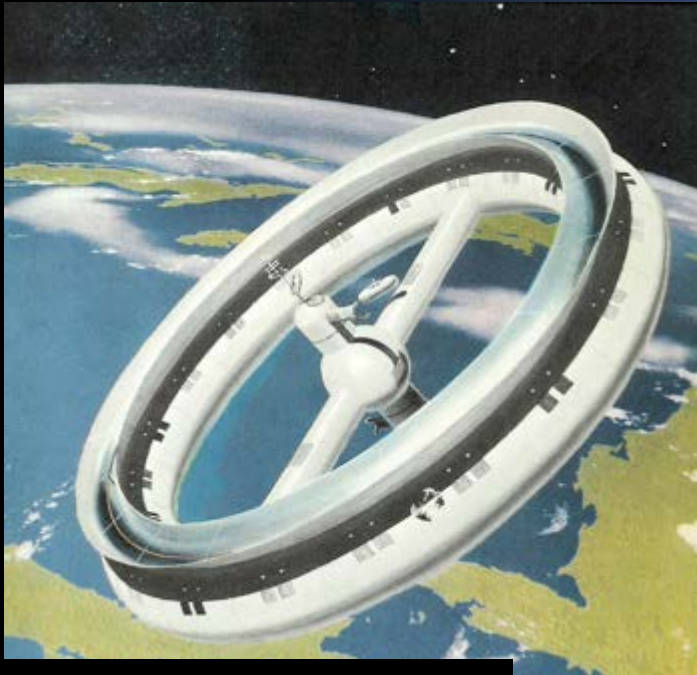
Historical AG Concepts



Tsiolkovsky (1903)



Noordung (1928)

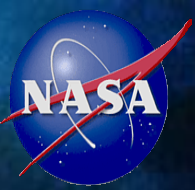


Von Braun (1952)



"Hermes" in The Martian movie (2015)

Why Has AG Never Been Implemented ?

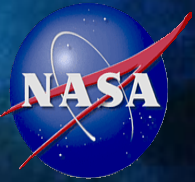


- Lack of definitive design requirements, especially acceptable AG levels and rotation rates.
- Perception of high vehicle mass and performance penalties.
- Incompatibility of resulting vehicle configurations with space propulsion options.
- Perception of complications associated with de-spun components such as antennae and solar arrays.
- Expectation of effective crew microgravity countermeasures.
- Space research focus on microgravity, not partial gravity.

Products Necessary to Resolve Open Questions

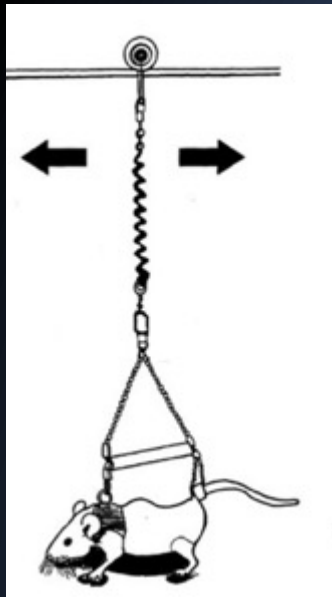
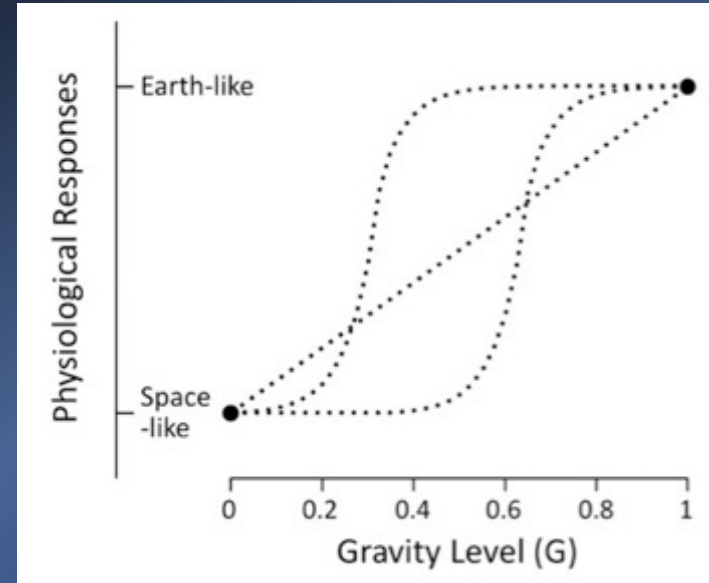
- | | | |
|--|--|--|
| <ul style="list-style-type: none">• Subjective Assessment<ul style="list-style-type: none">• Crew comfort• Crew time• Overall crew acceptance | <ul style="list-style-type: none">• Engineering Assessment<ul style="list-style-type: none">• Loads at interfaces with module/node• Vibrations, g jitters, noise• Heat load, air flow | <ul style="list-style-type: none">• Physiological Assessment – AG Prescription<ul style="list-style-type: none">• Optimal G level (radius & rotation rate)• Optimal AG duration/frequency• Feasibility of AG combined with exercise |
|--|--|--|

Artificial Gravity Level

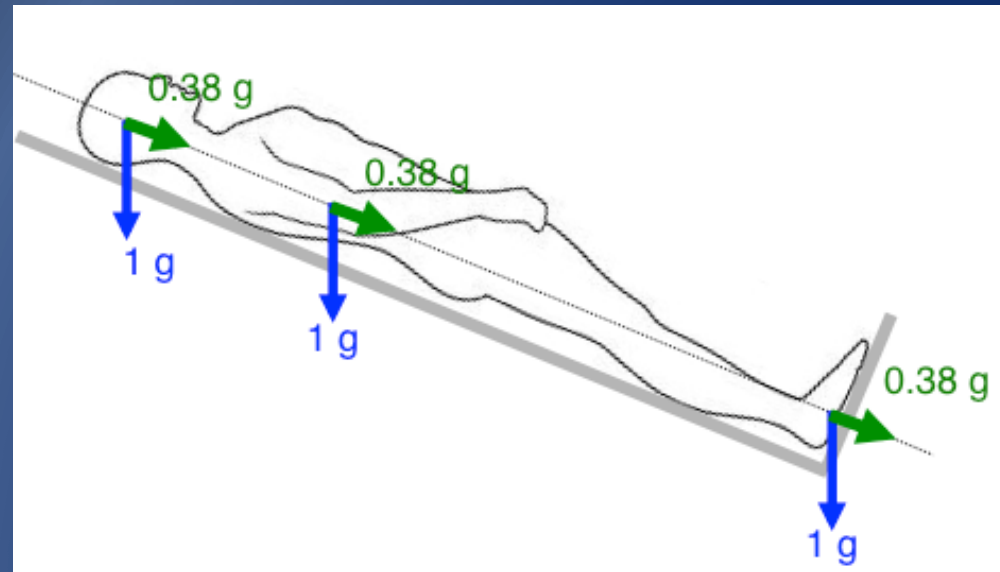


•G dose-physiological response

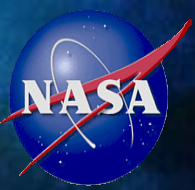
- Partial-G parabolic flight
- Body unloading
- Head-up tilt
- JAXA ISS mouse centrifuge



*Body-weight unloading
(Ellman et al. 2013)*

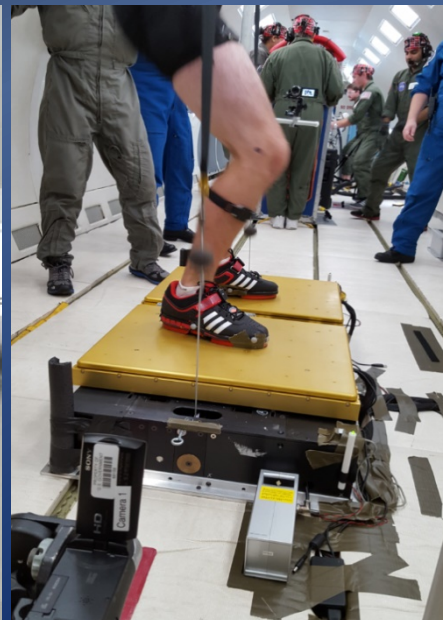
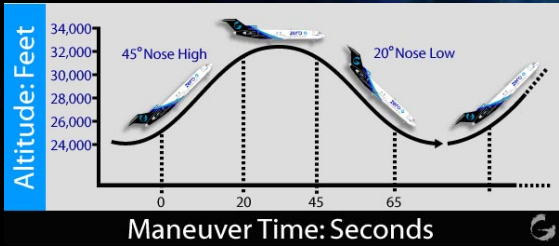
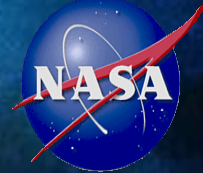


AG Summary



- **AG research overarching goal is to inform managers and mission designers as to the specific AG requirements and their costs and benefits for any given mission scenario.**
- **AG research projects, both ground- and space-based, exist worldwide.**
- **AG research is translational across species and physiological systems.**
- **AG research is multidisciplinary, combining physics, physiology, biology, human factors, and engineering issues.**

Parabolic Flight





ARGOS

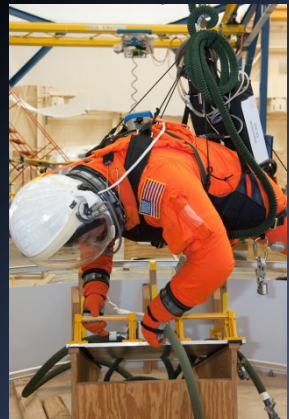


- ARGOS is a robotic system that simulates a reduced gravity environment
- ARGOS uses computer controlled electric motors to drive motion in all axes
 - Vertical system (Z-axis)
 - Connects and supports the test participant
 - Measures the load on the system with redundant in-line load cells that are constantly monitored by the control system
 - Control system commands the motor to raise or lower as the test participant while maintaining a constant offload force
 - Horizontal system (X, Y-axis)
 - Driven by electrical motors attached to friction drive wheels
 - Motion of test participant is measured by a cable angle sensor
 - The cable angle laser sensor provides data which commands the system to keep the lifting mechanism centered above the load
- [Backup](#)



HILT

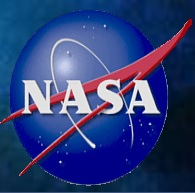
- Examples of Payloads in ARGOS



Unsuited Human Participants

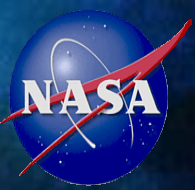
Suited Human Participants

Robotic Payloads



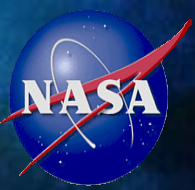
Collaborations

Research & Collaboration Opportunities



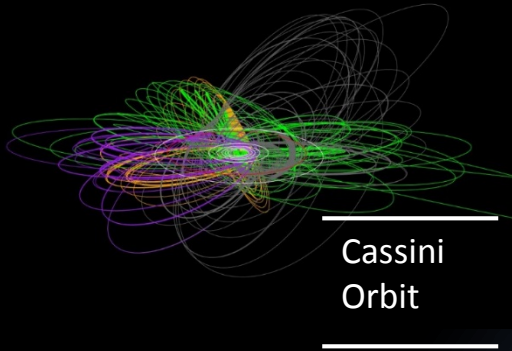
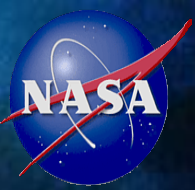
- OP3
- NSPIRES
- CASIS
- Space Biology

Summary



- Bone and muscle loss remain a serious risk to crew health.
- Our experience base is limited to 6 month missions.
- Quantify the exercise data we have today as a baseline from which we can continue to improve upon.
- Must apply lessons in bone mechanobiology with data being collected today to develop robust predictive algorithms.
- Identify new tools to help quantify loading profiles.
- Utilize ISS as a laboratory to conduct tech demos of new gadgets.
- Inspire the next generation of space life scientists and engineers to help find solutions to protecting human health during planetary exploration.

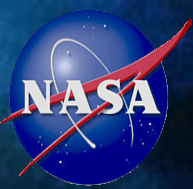
Choose YOUR trajectory



- Focus on the Fundamentals
- Be Persistent and Demonstrate Competence
- Network & Seek out Strong Mentors
- Communications is a key to making operations smooth: understand how it works, ask questions, and state expectations.
- Don't settle into the comfortable, Be Proactive and Create New Opportunities
- Work-life balance
- Follow your passion, love what you do, share it with others

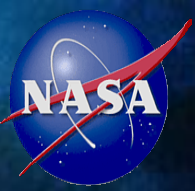
Thank you!

ありがとう!



Contact Info:
Dr. Andrea Hanson
andrea.m.hanson@nasa.gov

Back Up



Applying to be an Astronaut: Requirements



- **Must be US citizen.**
- **Qualifying degrees: Engineering, Biological Science, Physical Science, Computer Science, or Mathematics.**
- **Either 3 years of professional related experience, or 1,000 hours of pilot-in-command time in jet aircraft.**
- **Ability to pass the NASA long-duration Astronaut physical, which includes visual acuity is correctable to 20/20.**
- **Must meet anthropometric requirements (height and body measures) for the vehicle and EVA suit.**



Applying to be an Astronaut: Application Period

Record
18,300+
Applicants!



© International Space Station/Instagram



December 14, 2015	Vacancy Announcement opens in USAJOBS
February 18, 2016	Vacancy Announcement closes
February–September 2016	Qualified Applications reviewed to determine Highly Qualified applicants. Qualifications Inquiry form sent to Supervisors/References.
October–December 2016	Highly Qualified applications reviewed to determine Interviewees
February–April 2017	Interviewees brought to JSC for initial interview, medical evaluation, and orientation. Interviewees will be selected from the Highly Qualified group and contacted on a week-by-week basis.
May 2017	Finalists determined
June 2017	Astronaut Candidate Class of 2017 announced
August 2017	Astronaut Candidate Class of 2017 reports to the Johnson Space Center

Applying to be an Astronaut: The Interview



- Orientation
- Tour around JSC
- Anthropometric Measurements
- Robotic Assessment
- Written Psychological Exam
- Medical Questionnaire
- Workout with ASCRs
- The Interview: Tell us about yourself
- Meeting Other Astronauts
- Social