

THE SCIENCE OF

MUSCLES

AND BONES

Muscles and Bones in Space



by

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RESOURCES

For online presentations of each activity and downloadable slide sets for classroom use, visit <http://www.bioedonline.org> or <http://www.k8science.org>.

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TEAMING WITH BENEFITS

by Jeffrey P. Sutton, M.D., Ph.D., Director, National Space Biomedical Research Institute (NSBRI)

Space is a challenging environment for the human body. With long-duration missions, the physical and psychological stresses and risks to astronauts are significant. Finding answers to these health concerns is at the heart of the National Space Biomedical Research Institute's program. In turn, the Institute's research is helping to enhance medical care on Earth.



Dr. Jeffrey P. Sutton

The NSBRI, a unique partnership between NASA and the academic and industrial communities, is advancing biomedical research with the goal of ensuring a safe and productive long-term human presence in space. By developing new approaches and countermeasures to prevent, minimize and reverse critical risks to health, the Institute plays an essential, enabling role for NASA. The NSBRI bridges the research, technological and clinical expertise of the biomedical community with the scientific, engineering and operational expertise of NASA.

With nearly 60 science, technology and education projects, the NSBRI engages investigators at leading institutions across the nation to conduct goal-directed, peer-reviewed research in a team approach. Key working relationships have been established with end users, including astronauts and flight surgeons at Johnson Space Center, NASA scientists and engineers, other federal agencies, industry and international partners. The value of these

collaborations and revolutionary research advances that result from them is enormous and unprecedented, with substantial benefits for both the space program and the American people.

Through our strategic plan, the NSBRI takes a leadership role in countermeasure development and space life sciences education. The results-oriented research and development program is integrated and implemented using focused teams, with scientific and management directives that are innovative and dynamic. An active Board of Directors, External Advisory Council, Board of Scientific Counselors, User Panel, Industry Forum and academic Consortium

help guide the Institute in achieving its goals and objectives.

It will become necessary to perform more investigations in the unique environment of space. The vision of using extended exposure to microgravity as a laboratory for discovery and exploration builds upon the legacy of NASA and our quest to push the frontier of human understanding about nature and ourselves.

The NSBRI is maturing in an era of unparalleled scientific and technological advancement and opportunity. We are excited by the challenges confronting us, and by our collective ability to enhance human health and well-being in space, and on Earth. ◆

NSBRI RESEARCH AREAS

CARDIOVASCULAR PROBLEMS

The amount of blood in the body is reduced when astronauts are in microgravity. The heart grows smaller and weaker, which makes astronauts feel dizzy and weak when they return to Earth. Heart failure and diabetes, experienced by many people on Earth, lead to similar problems.

HUMAN FACTORS AND PERFORMANCE

Many factors can impact an astronaut's ability to work well in space or on the lunar surface. NSBRI is studying ways to improve daily living and keep crewmembers healthy, productive and safe during exploration missions. Efforts focus on reducing performance errors, improving nutrition, examining ways to improve sleep and scheduling of work shifts, and studying how specific types of lighting in the craft and habitat can improve alertness and performance.

MUSCLE AND BONE LOSS

When muscles and bones do not have to work against gravity, they weaken and begin to waste away. Special exercises and other strategies to help astronauts' bones and muscles stay strong in space also may help older and bedridden people, who experience similar problems on Earth, as well as people whose work requires intense physical exertion, like firefighters and construction workers.

NEUROBEHAVIORAL AND STRESS FACTORS

To ensure astronaut readiness for spaceflight, preflight prevention programs are being developed to avoid as many risks as possible to individual and

group behavioral health during flight and post flight. People on Earth can benefit from relevant assessment tests, monitoring and intervention.

RADIATION EFFECTS AND CANCER

Exploration missions will expose astronauts to greater levels and more varied types of radiation. Radiation exposure can lead to many health problems, including acute effects such as nausea, vomiting, fatigue, skin injury and changes to white blood cell counts and the immune system. Longer-term effects include damage to the eyes, gastrointestinal system, lungs and central nervous system, and increased cancer risk. Learning how to keep astronauts safe from radiation may improve cancer treatments for people on Earth.

SENSORIMOTOR AND BALANCE ISSUES

During their first days in space, astronauts can become dizzy and nauseous. Eventually they adjust, but once they return to Earth, they have a hard time walking and standing upright. Finding ways to counteract these effects could benefit millions of Americans with balance disorders.

SMART MEDICAL SYSTEMS AND TECHNOLOGY

Since astronauts on long-duration missions will not be able to return quickly to Earth, new methods of remote medical diagnosis and treatment are necessary. These systems must be small, low-power, noninvasive and versatile. Portable medical care systems that monitor, diagnose and treat major illness and trauma during flight will have immediate benefits to medical care on Earth.

For current, in-depth information on NSBRI's cutting-edge research and innovative technologies, visit www.nsbri.org.

OVERVIEW

Students learn about the changes that occur in bones and muscles while people are in space and then apply their knowledge of muscles and bones to suggest preventative solutions for those changes.



MUSCLES AND BONES IN SPACE

On Earth, muscles and bones are used to working against gravity to maintain posture and balance. In space, where the effects of gravity are almost absent, the muscles and bones of astronauts do not have to work as hard and become weaker. Bone rebuilding falls behind bone dismantling, and bones decrease in diameter and become less dense. The calcium removed from bones is permanently eliminated from the body in urine, leading to a condition similar to osteoporosis on Earth.

Muscles in space also become smaller and weaker through a process called atrophy. In addition, the fibers inside muscles change because most work in space involves short-duration, high intensity tasks.

The adaptation of muscles and bones to microgravity conditions does not have serious consequences in space, where astronauts do not need as much strength to keep their balance and move about. In fact, the bodies of people in space eventually reach equilibrium, called “space

normal,” with their new environment. This adaptation does, however, cause problems when astronauts return to an environment with the full force of gravity because their muscles and bones have become too weak to function as before.

Similar problems can be observed on Earth among people who are bedridden during a long illness, who have part of their bodies immobilized to allow a fracture to heal or who suffer from osteoporosis. Research to develop measures that will counter changes in muscles and bones in space will benefit these and many other people directly.

TIME

10 minutes setup; 30 minutes for activity

MATERIALS

- Copy of the student sheet

SETUP & MANAGEMENT

Provide resource materials on space topics.

PROCEDURE

1. Review the concepts presented in this unit. Discuss how lack of stress affects bones and muscles. Ask students to think of environments in which stress on the body is reduced, such as when on the space shuttle or space station, or during bed rest.
2. Hand out the student sheet and have each student complete it alone.
3. Have students share their drawings with the rest of the class. ◆

Effects of Lack of Movement

Have you or someone you know ever had a broken leg or arm? The limb probably had to be encased in a cast that would keep the broken pieces in place and allow them to mend. The lack of movement causes the muscles and bones inside the cast to become weaker. This usually can be observed once the cast is removed—the diameter of the newly healed arm or leg is noticeably smaller than the arm or leg that wasn't in a cast. Fortunately, normal use restores bone and muscle size and strength within a few weeks.

Something similar happens to the bones and muscles of astronauts who live and work in space.

SCIENCE, HEALTH & MATH SKILLS

GRADES 5–8

- Using resources to gather information
- Applying knowledge
- Drawing conclusions
- Presenting conclusions with supporting information

CONCEPTS

- Lack of stress causes bones and muscles to become weak.
- Astronauts must counteract the effects of lost stress on bones and muscles.

ACTIVITY

ON EARTH / IN SPACE

Maria and Michelle are identical twins who live together and have similar activities. They are special student astronauts with NASA. Both are participating in an experiment on muscles and bones. Tomorrow, Maria will go up in the space shuttle for a 10-day mission. Meanwhile, Michelle will stay on Earth and maintain her normal daily routine. When Maria returns to Earth, scientists will compare the bones and muscles in Maria's and Michelle's right arms. The scientists need your help to know what to expect when the 10-day mission is over.

1. Draw an inside view of Maria's and Michelle's right arms—after the mission—in the spaces below. Label the bones and muscles.



Maria's Right Arm.



Michelle's Right Arm

2. Describe how the two arms are different.

3. The scientists do not want the changes seen in Maria's arm to occur in the muscles and bones of astronauts on future missions. They need your help to design a diet and exercise program to prevent these changes. What would you suggest?
