



Sample Lesson: “Osteoporosis in Astronauts”

Objective

Discuss the various physiological effects of life on the moon such as alterations in bone geometry, a decrease in bone density, impaired fracture healing, decrease in cardiac mass, marrow failure, muscle atrophy, radiation, immunodeficiency, etc.

National Standards Met

NCSS 3—People, Places and Environments
NSES 3—Life Sciences

Osteoporosis in Astronauts?

Objectives

- Students will understand how the harsh space environment affects bone density.
- Students will understand that astronauts need to exercise in space to minimize tissue loss.
- Students will understand why tissue loss is an important aspect of preparation for long distance space travel.
- Students will understand rates of bone uptake and loss.

Suggested Grade Level

High School

Subject Area(s)

Life Science

Integrated Science

Biology

Astronomy

Timeline

1 to 1.5 class periods of one hour.

Background

Students should understand the basic concepts of bone and muscle form and function.

Students should have a basic understanding of the benefits of exercise for the human body.

Students should understand the properties of a microgravity environment.

Students should understand how objects react in a microgravity environment.

This lesson should be taught after the skeletal, muscular and endocrine systems have been introduced in a Biology, Life Science or Integrated Science class. In an Astronomy class, this lesson could be taught during a unit on long-term space expeditions or how the human body reacts to microgravity.

The breakdown of existing bone material (resorption) and the building of new bone material (growth) coexist in a delicate balance in 30 to 40 year-old healthy adults on Earth. The disruption of this balance typically causes a loss of bone density that researchers think is due to a mitigation of the growth process. Bone loss in space is a particularly relevant topic to life on Earth for several groups of individuals on Earth: patients confined to bed-rest for long periods of time, post-menopausal women and people that smoke and drink excessively.

Astronauts that perform long missions are at a greater risk for decreased bone mass, as the rate of bone loss is about 1% per month in space. It is not clear from the studies performed if that rate tapers off after extended periods of time, or if the rate is linear in microgravity. The rate of bone loss for astronauts in a month is comparable to an average 15% bone loss in men and 30% bone loss in women over a lifetime. It is essential that the mechanisms of bone loss and bone absorption be fully understood prior to humans traveling for long distances in space.

Exercise is the primary method of reducing the rate of resorption. However, exercise in space presents its own challenges, as there is no gravity for the muscles and bones to work against as on Earth. Astronauts must be weighted down to run on a treadmill, and resistance bands must be used instead of a traditional weight set to insure effective use of muscles and bones in space.

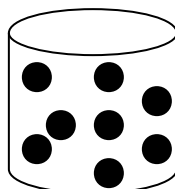
Materials

~200 large craft beads per group of two
Two containers per group
Jump rope
Ankle weights
Wrist weights
Therabands
Assorted home exercise equipment

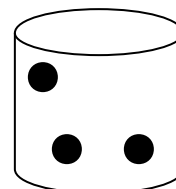
Lesson

1. A pair of students will have one container full of beads and one empty container. The beads in the first container represent calcium molecules in an astronaut's bone. Students will determine the length of mission for an astronaut. Their goal is to predict and determine how much bone density is lost during the mission they are managing.
2. Students will be given the rate of resorption, and they will remove the correct number of beads from the container per unit of time to reflect the overall bone loss of the astronaut during the space flight. They will place the 'lost bone density' beads in the empty container.
3. Record the findings and compare with other groups in the class to determine a trend based on length of time in space.
4. After the mission is over, students will then attempt to replace bone density by allowing the astronaut to take calcium supplements and perform weight-bearing exercises. At this time, they will add bone density beads back into the original astronaut container based on the rate of calcium uptake and the bone's ability to re-grow.

Astronaut



Calcium Deposit/Reserve



5. The pairs of students will brainstorm how to exercise without the use of gravity. Each group of two will then design an exercise program to address each of the major muscle groups with the intent that the program be used by individuals subjected to microgravity. They are welcome to incorporate materials provided by the teacher, or students may include equipment in their program that are not on-site. When developing their program they must consider the lack of space available on the space shuttle, the mass of the equipment, the effectiveness and versatility of the exercise apparatus chosen.

Extensions

- Students can search online for interview transcripts with the astronauts and cosmonauts.
- Students can find additional information to support their initial predictions using the NASA website <http://www.nasa.gov>

Evaluation/Assessment

- Students will write a paragraph describing the length of the mission, the amount of bone density lost and the amount regained.
- Students will demonstrate an understanding of rate of loss and uptake of bone material in another paragraph describing the results.
- Students will demonstrate understanding of the physiological stresses the body undergoes in space.
- The worksheet in the addendum will be filled in to evaluate understanding of how to build back the muscles, bones and how to maintain cardiovascular fitness.

Resources

Rocketry and the Biology of Living in Space class materials-specifically the lesson topic Human Physiology in Space

<http://weboflife.ksc.nasa.gov/currentResearch/currentResearchGeneralArchives/weakKnees.htm>

<http://www.tamu.edu/univrel/aggedaily/news/stories/archive/100396-3.html>

<http://www.starship2040.com/exerciseh.html>

<http://www.montanap.org/osteoporosis.htm>

<http://www.nsbri.org/HumanPhysSpace/codus6/spaceflight.html>

Addendum

Muscle Group Affected	Apparatus Used	Exercise Performed	Duration of Exercise	Intensity of Exercise	Effectiveness against bone loss	Effectiveness in maintaining cardiovascular fitness
Quadriceps						
Hamstrings						
Gastrocnemius						
Biceps						
Triceps						
Pectorals						
Deltoids						
Latisimus Dorsi						
Abdominals						