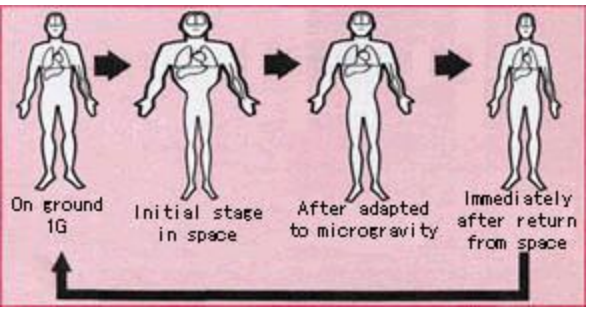
Microgravity Orientation

Human Physiology

Microgravity is something most people are aware of in a superficial way, primarily through movies and television that depict space travel. Science educators, and students, can explain the concept of microgravity and free-fall using Newtonian physics. The purpose of this series is to increase your understanding of how microgravity effects the lives of astronauts during extended periods off the Earth, conducting science experiments, and working in space.

Like all life on Earth, humans have evolved under the umbrella of our planets gravity. Removing gravity effects virtually every system in our bodies and causes effects that range from uncomfortable to life threatening. Over the years HUNCH participants have worked on numerous projects that reduce discomfort, and help the body compensate for conditions that threaten long term health. This overview focuses on the cardiovascular, and skeletal system. For a more in-depth understanding links are provided at the end of the document.



As soon as astronauts arrive in microgravity, and while they remain on the International Space Station, blood and other body fluids are pushed "upward" from the legs and abdomen toward the heart and head. This fluid shift causes a decrease in the amount of blood and fluid in the heart and blood vessels even while astronauts experience swelling in the face and head[1]. In addition to the cardiovascular system there are also changes to the brain, eyes, and neurological function. The apparent increase in fluid within the skull is thought to increase brain pressure, which can cause hearing loss, brain edema and deformation of the eye known as Spaceflight Associated Neuro-ocular Syndrome (SANS). In microgravity the heart changes it shape from an oval (like a water-filled balloon) to a round ball (an air filled balloon), and space causes atrophy of muscles that on Earth work to constrict the blood vessels, so they cannot control blood flow as well[1].
When astronauts return to Earth gravity normal blood flow to the abdomen and legs resumes. Initially this can cause orthostatic hypotension, making it difficult to stand or feeling light-headed, and in some instances fainting.

Microgravity is also associated with significant changes in the skeletal system. Under normal circumstances, bone remodeling is an adaptive and balanced process where bone resorption and formation are coupled to regulate homeostasis of bone tissue9. The overall process relies on osteoblasts and osteoclasts acting in concert to regulate bone formation and resorption, respectively[2]. In microgravity there is a 1-2% loss in bone mass per

month. Microgravity reduces the loading on weight-bearing bones, resulting in adaptive changes that increase bone resorption and inhibit bone formation[2]. Bone loss leads to overall weakening of bone and the risk of fractures. On very long space missions, such as the asteroid belt, or Mars, this presents a significant health risk. It is reported that the time required for recovery to pre-flight levels is reportedly longer than the actual mission. Numerous measures are currently employed to help reduce this risk including strenuous exercise and diet[3].

HUNCH students working on projects for Design and Prototype or Health and Biomedical need a comprehensive understanding of these issues. Additional resources are provided below for you, and your students.

https://www.nasa.gov/mission_pages/station/research/station-science-101/cardiovascular-health-in-microgravity/

https://www.issnationallab.org/iss360/going-to-space-to-help-improve-cardiovascular-disease-treatment-on-earth/

https://www.youtube.com/watch?v=DR23ipzB_7w

https://www.issnationallab.org/iss360/skeletons-in-space-studying-bones-in-microgravity/

https://www.nasa.gov/content/bone-and-mineral-evaluation-and-analysis

https://letstalkscience.ca/educational-resources/stem-in-context/why-a-trip-outer-space-could-be-bad-your-bones

https://www.youtube.com/watch?v=NMZDhJiKw3k

References:

1. https://www.nasa.gov/mission_pages/station/research/station-science-101/cardiovascular-health-in-microgravity/#:~:text=In%20microgravity%20the%20heart%20changes,control%20blood%20flow%20as%20well.

2. https://www.nature.com/articles/s41526-022-00194-8

3. https://www.nasa.gov/mission_pages/station/research/station-science-101/bone-muscle-loss-in-

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microgravity/#:~:text=Research%20on%20Earth%20and%20on,to%20perform%20high%20intensity%20workouts.