Space Physiology

Accompanying video: https://youtu.be/KRDAsujZD2s

Bergita Ganse, Manchester Metropolitan University

Julia Attias, Kings College London

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Many body functions and adaptation processes in space are unlike what we know from Earth and often counter-intuitive. When briefing spacefarers before a flight, space physiology should not be neglected, as it is highly relevant for well-being and health. Strong G-forces at start and landing, weightlessness, isolation and exposure to a misanthropic environment lead to a number of changes in the human body, including muscle and bone loss, and adaptations of the cardiovascular system. Exposure to weightlessness and space radiation sometimes even has consequences for health later in life. Long-term space missions, for example to Mars, will require extensive countermeasures optimized to keep the crew healthy.

Part 1 – Physiological challenges in spaceflight - shrinking hearts and shrimp cocktail

Exposure to microgravity leads to a fluid shift within the body that causes a "puffy face" and "bird legs". The pressure sensors in the chest and neck sense increased blood volume and induce the excretion of 1.5 liters of water to regulate the fluid load. The taste buds on the tongue swell and change the food preferences of spacefarers. The heart has less work to do and shrinks. Information mis-match between the visual system and inner ear causes space sickness with nausea and vomiting. The intervertebral discs grow, the spine elongates by approximately 5.5 cm on average and causes "Space Adaptation Back Pain" that usually lasts for a few days. If not used, muscles deteriorate and not only the muscle volume and force decrease, but also the fiber type composition changes. These and many other physiological challenges need to be addressed when planning long-term spaceflight to hopefully receive healthy and happy space explorers back on Earth.

Part 2 – How to counter human deconditioning in microgravity

The current countermeasure program for astronauts aboard the ISS consists of a combination of strategies to help tackle the differing physiological adaptations. For example, both aerobic – using a treadmill and bicycle ergometer – and resistance – using the Advanced Resistive Exercise Device – exercise countermeasures help in keeping the cardiovascular system active and minimizing atrophy of lower-body muscles. From a fundamental point of view, when you strip away the element that our physiological systems were built to revolve around i.e., gravity, then the optimal solution, intuitively, is to recreate it. Many concepts have been conceived in an attempt to recreate gravity, or at least the loading stimulus that gravity provides us with in. Human centrifugation, which creates artificial gravity via centrifugal forces have been implemented in bed rest studies – an established model of microgravity. In an ideal world, a human centrifuge would be placed on board crafts for future space missions, though are logistically challenging to implement i.e. the vast volume they would need to occupy vs. a spacecraft that will undoubtedly be too small. A number of ideas have been thought up in an attempt to tackle these logistical challenges. One light-weight example is a skin-tight garments using elastic resistance have been developed which provide axial body loading in the longitudinal axis in attempt to maintain a loading stimulus to a number of physiological systems as well as assisting in attenuating spinal elongation associated with microgravity exposure.

Ultimately, astronauts will no doubt require a combination of countermeasures to maintain the integrity of their physiological systems in space, though the optimal concoction is yet to be determined.

Questions

1. **Which medical events or symptoms are usually experienced during the first day of a spaceflight? What do space tourists need to know?**

2. **Why are spacefarers who return from a mission usually carried and do not walk themselves directly after landing?**

3. **In a pub someone tells you about the plan to secretly fly to Mars to be there first. She asks you how you would implement the training in the spaceship. What is your recommendation?**