A first order physical model of a bone cell to validate a mathematical model for bone strain amplification in microgravity

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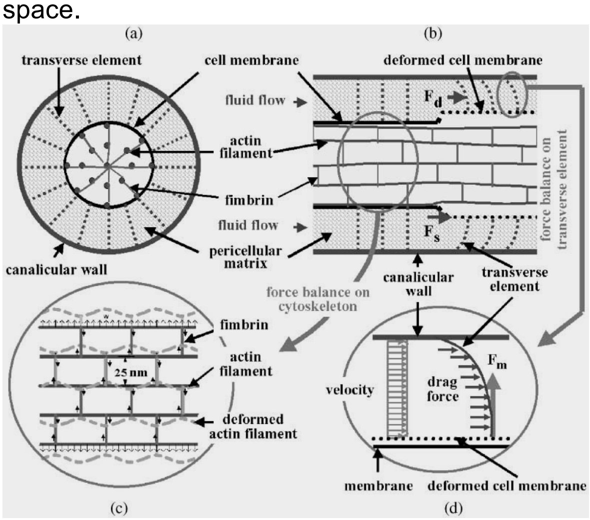
Brief Summary

Bone loss is a key issue facing astronauts in spaceflight. Currently, it has been mitigated by exercise and bisphosphonates, but more countermeasures are required. A physical model of a bone cell was created to validate a mathematical model determining how fluid flow might stimulate new bone development.

Abstract

In the past, astronauts have lost more bone mass during a month in space than a postmenopausal woman loses in a year. This has been mitigated by astronauts using the Advanced Resistive Exercise Device (ARED) on the International Space Station (ISS) and taking bisphosphonate drugs. However, the ARED is large and could be difficult to fit on crew capsules designed for landings on planetary surfaces. As such, new research and development is required to provide astronauts with a greater suite of options to combat bone loss. Strangely, the skull gains bone mass in space.



Numerous animal studies, including one of mice exposed to 15 days of spaceflight on the STS-131 space shuttle mission and another involving tail-suspended rats on Earth, confirm this effect in actual and simulated microgravity. It is unclear why this phenomenon occurs, but fluid shifts experienced by organisms in microgravity may play a role. A paper by You et al. outlines a mathematical model of how fluid flow in the actin cytoskeleton of an osteocyte (i.e. bone cell) might amplify the strain experienced by it, causing the cell to make more osteocytes. To validate this, a student team from the University of Toronto Department of Mechanical Engineering constructed a first order physical model of an osteocyte to measure this strain amplification as experienced in cortical bone in the skull. It consists of an idealized bone cell canaliculus in a flow loop with four gauges on the cell process membrane to measure strain. A mechanical pump simulates fluid flow through bone. Currently, improvements are being made to the model. The goal is to achieve a technology readiness level (TRL) of 4 so that it can be flown on a parabolic aircraft in 2018.