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AN IN VITRO ANALYSIS OF OSTEOBLAST TRANSCRIPTION FACTORS IN LOW EARTH ORBIT VIA ISS INTERNAL PAYLOAD AND CUBESAT FORM FACTOR

Abstract

For the past sixty years, humans have explored the edges of space, and for the past twenty years, the International Space Station (ISS) has offered continuous access to Low Earth Orbit (LEO). Currently 5-7 person 'Expeditions' spend an average of 4-6 months aboard the ISS conducting a variety of research missions. While on orbit, several astronaut body systems are affected, including the loss of a significant amount of bone mass. For humans to establish a permanent presence off of Earth and to become a multi planetary species, a better understanding is needed to mitigate bone loss due to skeletal unloading. This paper suggests ISS payloads and smallsats may provide a means to conduct that research.

Among the many physical changes to the human body experienced during spaceflight. One issue of particular concern is the significant muscle and bone loss. According to the Canadian Space Agency, astronauts lose an average of 1-2

Osteoblasts and osteoclasts are two of the primary cells of bone maintenance, formation, and resorption. Osteoblasts (OB) are cells that form new bone and adapt to differences in loading and weight bearing, while osteoclasts (OC) break down existing bone to initiate bone remodeling. Osteocytes are mature and OB cells that are enclosed within the bone matrix. Among the numerous hormones and transcription factors which coordinate OB formation and OC resorption are calcitonin (CT) and parathyroid hormone (PTH). PTH indirectly activates OBs and OCs through a series of catabolic reactions. Several genetic factors can also play a role in bone remodeling, including AP-1 and chemokine as well as the FOS and JUN family of proteins.

Upon reaching orbit, the unloaded skeletal system experiences an almost immediate loss of bone mineral. The normally equivalent rates of formation and resorption in 1G are interrupted, with the resorption rates exceeding formation rates. Without loading there is no apparent need for OBs to maintain formation rates. This physiological response becomes problematic at the conclusion of long-term spaceflights (e.g. arriving at or returning from Mars). Astronauts aboard the ISS have utilized mechanical, nutritional, and pharmaceutical countermeasures to address bone loss. The current regimens need to be optimized to minimize risks associated with injuries and kidney stones due to elevated blood plasma calcium levels. This paper will examine current research and propose internal ISS experiments and novel CubeSat payload which may be compared to ground based controls.