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FRACTURE RISK IN SPACEFLIGHT AND POTENTIAL TREATMENT OPTIONS

Abstract

Understanding the chronic effects of a microgravity environment on bone is essential, given that humans are now considering new long-distance spaceflight missions. With ambitions to send astronauts into deep space in the next few decades, it is important to note that the negative effects of long-duration spaceflight on bone may increase the risk of musculoskeletal injuries. As a result, management options for these types of injuries, particularly fractures, should be addressed prior to future deep-space missions. The objective of this study was to determine high-risk bone fracture areas after long-duration spaceflight, and identify management protocols for those fractures. A literature search was conducted for information on current fracture risk predictive models, and suggestions for treatment. It is well known that bone mineral density (BMD) decreases during long-duration spaceflight. This is likely the result of decreased load on bone in a microgravity environment, which leads to an uncoupling between bone resorption (increased) and bone remodeling (stable or decreased), also causing diminished bone fracture healing. While the risk of fracture in a microgravity environment is believed to be low, upon re-entering a gravity environment (such as the Earth, the Moon, or Mars), the potential risk for fracture increases. The Bone Fracture Risk Model (BF x RM) is an algorithm developed to determine the probability of fracture at a particular skeletal site in a given loading scenario. As predicted by this model, there is greater fracture risk of the lumbar spine, femoral neck, and wrist, especially with increased mission duration and subsequent physical activity once re-introduced to a gravity environment. While there are many viable suggestions for mitigating bone fracture risk, there are limited proven management options. Exercise is part of a fundamental long-duration spaceflight strategy to mitigate BMD loss, and BMD improvement with exercise has been augmented by the introduction of the advanced resistance exercise device (ARED) on the International Space Station. Additionally, studies have shown that supplementation with bisphosphonates has an additive effect for preventing bone loss. If a fracture were to occur, promising treatment options to improve bone fracture healing in space (in addition to standard management modalities such as splinting) include the use of low-magnitude, high-frequency vibration, as well as subcutaneous injections of parathyroid hormone coupled with low-intensity pulsed ultrasound. In conclusion, the best strategy for reducing musculoskeletal injuries for deep-space missions will be a combination of BMD loss reduction coupled with improvements in management protocols for potential fractures.