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### **RECOMMENDED METHODS FOR MONITORING SKELETAL HEALTH IN ASTRONAUTS TO DISTINGUISH SPECIFIC EFFECTS OF PROLONGED SPACEFLIGHT:**

**MOTIVATION:** NASA uses areal bone mineral density (aBMD) by dual-energy X-ray absorptiometry (DXA) to monitor skeletal health in astronauts after typical 180-day spaceflights. The osteoporosis field and NASA, however, recognize the insufficiency of DXA aBMD as a sole surrogate for fracture risk. This is an even greater concern for NASA as it attempts to expand fracture risk assessment in astronauts, given the complicated nature of spaceflight-induced bone changes and the fact that multiple 1-year missions are planned. In the past decade, emerging analyses for additional surrogates have been tested in clinical trials; the potential use of these technologies to monitor the biomechanical integrity of the astronaut skeleton will be presented.

**OVERVIEW:** An advisory panel of osteoporosis policy-makers provided NASA with an evidence-based assessment of astronaut biomedical and research data. The panel concluded that spaceflight and terrestrial bone loss have significant differences and certain factors may predispose astronauts to premature fractures. Based on these concerns, a proposed surveillance program is presented which a) uses Quantitative Computed Tomography (QCT) scans of the hip to monitor the recovery of spaceflight-induced deficits in trabecular BMD by 2 years after return, b) develops Finite Element Models [FEM] of QCT data to evaluate spaceflight effect on calculated hip bone strength and c) generates Trabecular Bone Score [TBS] from serial DXA scans of the lumbar spine to evaluate the effect of age, spaceflight and countermeasures on this novel index of bone microarchitecture.

**SIGNIFICANCE:** DXA aBMD is a widely-applied, evidence-based predictor for fractures but not applicable as a fracture surrogate for premenopausal females and males <50 years. Its inability to detect structural parameters is a limitation for assessing changes in bone integrity with and without countermeasures. Collective use of aBMD, TBS, QCT, and FEM analysis for astronaut surveillance could accommodate NASA's aggressive schedule for risk definition and inform a NASA-developed model which assesses the probability of overloading bones during mechanically-loaded mission tasks and possibly for physical activities after return to Earth.

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