

Patterns of Femoral Neck Bone Loss in Spinal Cord Injury and in Spaceflight

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Both spaceflight and spinal cord injury (SCI) cause lower limb disuse, hence SCI has been proposed as a model of space-flight bone loss. Hip DXA scans (Hologic QDR1000) were obtained within 10 weeks of acute SCI and at 3 months follow-up in 7 paraplegic and tetraplegic subjects enrolled in a placebo controlled trial of an intravenous bisphosphonate. Data were added from two untreated male adolescent SCI patients with 6 month follow-up. Scans were analyzed with the Hip Structure Analysis (HSA) program that measures BMD and geometric properties in narrow regions across the proximal femur. Measurements were compared to an earlier analysis on 19 Russian Cosmonauts, averaging 178 days (126 to 312) on the Mir Space Station. Rates of change were computed as percent change from baseline or pre-flight divided by time (months) to follow-up or post-flight, for SCI or Cosmonauts, respectively.

Mean rates of change (\pm SD) at the femoral neck are compared in the Figure. BMD, cross-sectional area (CSA), cortical thickness and section modulus (Z) each decrease while buckling ratio increases and width changes are non-significant, in both SCI and microgravity. Rates of change are much greater among cosmonauts although the difference is at least partially due to lack of change in some treated SCI subjects. As expected, the patterns of change in mechanical properties are similar in the two disuse conditions, resulting in a consistent decline in bending (Z) and axial (CSA) strength with an accompanying increase in cortical instability (BR = buckling ratio). This is unlike the aging pattern even in postmenopausal women, where increasing bone width tends to maintain bending strength despite net bone loss. Common to both types of bone loss is a reduction of density and an increase in buckling ratio.

We conclude that SCI is a good ground-based model of spaceflight bone loss and unlike aging, bone changes lack evidence of mechanical homeostasis. While preliminary, the faster degradation of bone geometry in space-flight compared to SCI suggests that space flight conditions, perhaps because of altered lower limb fluid dynamics, are more deleterious to the hip than disuse alone.

