**Expanding the Description of Spaceflight Effects beyond Bone Mineral Density [BMD]: Trabecular Bone Score [TBS] in ISS Astronauts**. JD Sibonga, ER Spector, LJ King, HJ Evans, SA Smith

Dual-energy x-ray absorptiometry [DXA] is the widely-applied bone densitometry method used to diagnose osteoporosis in a terrestrial population known to be at risk for age-related bone loss. This medical test, which measures areal bone mineral density [aBMD] of clinically-relevant skeletal sites (e.g., hip and spine), helps the clinician to identify which persons, among postmenopausal women and men older than 50 years, are at high risk for low trauma or fragility fractures and might require an intervention. The most recognized osteoporotic fragility fracture is the vertebral compression fracture which can lead to kyphosis or hunched backs typically seen in the elderly. DXA measurement of BMD however is recognized to be insufficient as a sole index for assessing fracture risk (NIH Consensus Development Panel on Osteoporosis Prevention, Diagnosis and Therapy. JAMA. 2001;285(6):785-795). DXA's limitation may be related to its inability to monitor changes in structural parameters, such as trabecular vs. cortical bone volumes, bone geometry or trabecular *micro*architecture. Hence, in order to understand risks to human health and performance due to space exposure, NASA needs to expand its measurements of bone to include other contributors to skeletal integrity.

To this aim, the Bone and Mineral Lab conducted a pilot study for a novel measurement of bone microarchitecture that can be obtained by retrospective analysis of DXA scans. Trabecular Bone Score (TBS) assesses changes to trabecular microarchitecture by measuring the grey color "texture" information extracted from DXA images of the lumbar spine. An analysis of TBS in 51 ISS astronauts was conducted to assess if TBS could detect 1) an effect of spaceflight and 2) a response to countermeasures independent of DXA BMD. In addition, changes in trunk body lean tissue mass and in trunk body fat tissue mass were also evaluated to explore an association between body composition, as impacted by ARED exercise, and bone microarchitecture.

The pilot analysis of 51 astronaut scans of the lumbar spine suggests that, following an ISS mission, DXA BMD and TBS are detecting different effects of ARED exercise and of ARED + Bisphosphonate on the lumbar spine of astronauts. There is emerging evidence associating reduced TBS with terrestrial metabolic bone disorders where a TBS <1.200 is associated with "degraded" while > 1.350 is associated with "normal." However, it is not possible to conclude how the spaceflight-induced changes in TBS increase risk for vertebral fractures in the astronaut or if changes in body composition of the trunk region could be an indirect method of assessing exercise effect on bone microarchitecture. More importantly, this pilot analysis demonstrates a new, minimal risk approach for monitoring changes to vertebral bone microarchitecture. This method could help assess the combined skeletal effects of spaceflight with the effects of aging in the astronaut after return to Earth.

| | | **TBS (mean ± SD)** | | | | **DXA BMD (mean ± SD)** | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **n** | **Pre mm$^{-1}$** | **Post mm$^{-1}$** | **Change mm$^{-1}$** | **%Ch/Mo** | **Pre g/cm$^2$** | **Post g/cm$^2$** | **Change g/cm$^2$** | **%Ch/Mo** |
| **Pre-ARED** | 24 | 1.447 ± 0.07 | 1.404 ± 0.09 | -0.043* ± 0.04 | -0.53 ± 0.54 | 1.067 ± 0.10 | 1.023 ± 0.09 | -0.044* ± 0.04 | -0.71 ±0.51 |
| **ARED** | 20 | 1.413 ± 0.08 | 1.416 ± 0.08 | 0.003 ± 0.03 | 0.03 ± 0.50 | 1.094 ± 0.11 | 1.071 ± 0.11 | -0.023* ± 0.03 | -0.37 ± 0.51 |
| **Bisphosphonate+ ARED** | 7 | 1.422 ± 0.07 | 1.401 ± 0.09 | -0.021 ± 0.05 | -0.27 ± 0.64 | 1.038 ± 0.14 | 1.067 ± 0.14 | 0.029 ± 0.04 | 0.56 ± 0.87 |

Significant (P<0.05) Positive Pearson correlations between changes in TBS and Body Composition for total body fat mass (r=0.3, p<0.03), trunk mass (r=0.40, p< 0.004) and trunk fat (0.33<0.02). ARED: Advanced Resistive Exercise Device