TBS (Trabecular Bone Score) expands understanding of spaceflight effects on the lumbar spine of long duration astronauts

Scott. A. Smith[1], Nelson Watts[2], Didier Hans[3], Adrian LeBlanc[4], Elisabeth Spector[1], Harlan Evans[1], Lisa King[1], Jean Sibonga[5]; [1]Wyle, Houston TX, [2]Mercy Hospital, Cincinnati, Ohio, [3]Lausanne University Hospital, Switzerland, [4]USRA, Houston, TX, [5]NASA JSC, Houston TX.

Background: Bone loss due to long-duration spaceflight has been characterized by both DXA and QCT serial scans. It is unclear if these spaceflight-induced changes in bone mineral density and structure result in increased fracture incidence. NASA astronauts currently fly on 5-6-month missions on the International Space Station (ISS) and at least one 12-month mission is planned. While NASA has measured areal BMD (by DXA) and volumetric BMD (by QCT), and has estimated hip strength (by finite element models of QCT data, no method has yet been used to examine bone microarchitecture from lumbar spine (LS). DXA scans are routinely performed pre- and post-flight on all ISS astronauts to follow BMD changes associated with space flight. Trabecular Bone Score (TBS) is a relatively new method that measures grey-scale-level texture information extracted from lumbar spine DXA images and correlates with 3D parameters of bone micro-architecture. We evaluated the ability of LS TBS to discriminate changes in astronauts who have flown on ISS missions and to determine if TBS can provide additional information compared to DXA.

Methods: LS (L1-4) DXA scans from 51 astronauts (mean age, 47 ± 4) were divided into 3 groups based on the exercise regimes performed while onboard the ISS. Pre-ARED (exercise using a load-limited resistive exercise device, <300lb), ARED (exercise with a high-load resistive exercise device, up to 600lb) and a Bisphos group (ARED exercise and a 70-mg alendronate tablet once a week before and during flight, starting 17 days before launch). DXA scans were performed and analyzed on a Hologic Discovery W using the same technician for the pre- and postflight scans. LSC for the LS in our laboratory is 0.025 g/cm^2. TBS was performed at the Mercy Hospital, Cincinnati, Ohio on a similar Hologic computer. TBS precision was calculated from 16 comparable test subjects (0.0XX g/cm^2). Data were preliminary analyzed using a paired, 2-tailed t-test for the difference between pre- and postflight means.

Results:

		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
Bisphos+ 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

*P < 0.05 by Student's paired t-test for difference between pre- and postflight means

Interpretation: Our data suggest that

- TBS and DXA both detected significant decrements in the lumbar spine in these pre-ARED astronauts, not unexpected given the insufficient loads provided by this early exercise device.
- TBS did not detect significant changes in the ARED or Bisphos+ARED groups while DXA did detect significant changes in the ARED astronauts.
- These findings suggest that DXA and TBS are detecting independent effects of bone loss interventions tested in ISS astronauts in space, which may be due to distinct effects of interventions on mineral content of separate cortical vs. trabecular bone.

Conclusion:
TBS, in conjunction with DXA BMD, may provide additional insight into the nature of changes (or lack thereof) in the microstructure of trabecular bone and the areal BMD of vertebral bodies.