Different time courses of bone losses in the cortical and trabecular compartments in different experimental immobilization models

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Introduction: Past research has shown that different parts of the skeleton respond differently to microgravity exposure and to unloading. This is true for different anatomical regions (Vico, et al. 2000), as well as for different tissue compartments (Lang, et al. 2006). In particular, it has been suggested recently that bone losses in response to experimental bed rest (Rittweger, et al. 2009) as well due to spinal cord injury (Rittweger, et al. 2010) are more pronounced from the cortical than from the trabecular compartment. The present paper therefore compares the time course of trabecular and cortical bone losses from the distal tibia epiphysis in four past studies.

Materials and Methods: Previously published data were re-analyzed from the control groups of a) the long term bed rest (LTBR) study in Toulouse (90 days of -6° head-down-tilt, N = 9), b) the 1st Berlin Bed Rest (BBR) study (56 days horizontal bed rest, N = 10), c) the Valdoltra 2007 (Valdo07) study (35 days of horizontal bed rest, N = 10), and d) the unilateral lower limb suspension (ULLS) study (24 days of one-legged limb suspension, N = 8). Across all four studies, peripheral quantitative computed tomography (pQCT) was used in the same way to study bone losses. Scans were obtained at 4% of the tibia’s length from its distal end, and subsequent image analysis identified the trabecular region as the inner 45% of the total bone area. The cortical compartment was defined as all pixels with apparent volumetric bone mineral density (vBMC) > 480 mg/cm³. Deviations from baseline were computed for all measurement days during the immobilization period and during follow-up, and one-sample t-tests were performed to assess statistical significance of these deviations.

Results: Bone losses from the cortical compartment were almost linear over time and tended to start from the first day of the immobilization phase. They were comparable across studies and became significant from the 14th day of immobilization onwards (exception: day 21 of ULLS, P = 0.088). Trabecular bone losses, by contrast, were not significant before the 31st day of immobilization, and in the ULLS study there was an increase rather than a decrease in trabecular vBMC between the 7th day of immobilization and the 4th day of recovery. Recovery of bone losses during follow-up measurements tended to be balanced between compartments and across studies.

Discussion: This systematic data analysis clearly demonstrates that immobilization-induced bone losses precede trabecular bone losses by approximately 14 days, irrespective of whether the immobilization is performed in -6° HDT, horizontal or vertical position. The high bone remodelling rate on the endocortical envelope offers itself as a likely explanation for the readiness of cortical losses. The most striking finding of this paper, however, is the trabecular vBMC gain during the immobilization phase of the ULLS study. Whether this finding is due to a) the vertical immobilization model, b) the greater measurement frequency as compared to the other studies, or c) the fact that only one leg was immobilized in the ULLS study should be addressed by future studies.

References

