rat hypergravity trabecular bone bone morphometry

TRABECULAR BONE ARCHITECTURE IN THE RAT, NORMALLY AND AFTER LONG-TERM EXPOSURE TO 2.5 G

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Introduction It is well established that mechanical loading is important for the maintenance of the skeleton. Several studies have shown that exposure to hypergravity decreases body weight, femur mass, and femur size compared to controls[2,4]. The femur size relatively to body weight, and the wall thickness of the shaft may increase however, resulting in increased bone strength[1,3,4]. On the other hand, hypergravity may immobilize the animal, resulting in decreased bone strength[5]. Little is known about the trabecular structure in bones exposed to hypergravity. In this study we addressed the following question. What is the influence of long-term exposure of 2.5 g to bone architecture in male rats?

Methods Three-week old Long-Evans rats were raised at 2.5 g in a centrifuge for 38 weeks (HG-group-1; N=2). Control rats were raised under normal conditions (N=2). In addition, rats were procreated, born and raised under 2.5 g conditions for 33 weeks (HG-group-2; N=3). At the end of the experiment, the body weight was measured. The proximal femur of each rat was scanned in a micro-CT. A 2x2x2mm^3 volume of interest of the trabecular region in the femoral head was segmented and evaluated for trabecular bone density (BV/TV), trabecular thickness (Tb.Th), ratio of bone surface to bone volume (BS/BV), and degree of anisotropy. In addition, the diameters of the femoral head and neck were determined using 3D reconstructions (Fig 1).

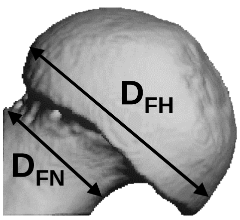

Figure 1: measurement of femoral head (D_{FH}) and femoral neck (D_{FN}) diameter.

Results BV/TV was similar for all groups (Fig 2). Compared to controls, total body weight was decreased by 16% for HG-1 and 29% for HG-2 (Fig 2). For HG-1, but not for HG-2, the trabecular thickness was decreased and BS/BV was increased by about 5% compared to controls (Table 1). Changes in anisotropy were negligible. The diameters of the femoral head and neck in the control rats were larger than in the rats exposed to hypergravity, but not significantly (Table 1).

Discussion These preliminary results indicate that the trabecular architecture in the femoral head hardly changed when exposed to 2.5 g. It should be noted that the HG-2 group was not age-matched compared to the other groups; additional controls are required. Furthermore, the femoral head contains a growth-plate, which might affect the results.

Since bone adapts to changes in mechanical load, it was expected that BV/TV would increase under hypergravity conditions. There are at least two possible explanations why this was not observed, each requiring additional investigation. Firstly, the cortical thickness, femoral mass, and femoral length were not measured but could be different compared to controls[1,2,3], so that adaptation to hypergravity conditions might be more at the global, cortical level than at the trabecular level. Secondly, it is possible that the activity of HG-rats was less compared to controls. This would result in decreased dynamic stimulation of the bone so that the unchanged BV/TV still may satisfy the mechanical demands of the rats exposed to hypergravity.

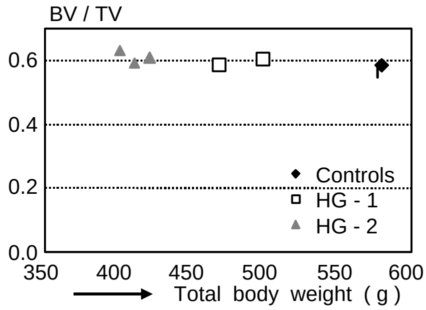

Figure 2: Trabecular bone density as a function of total body weight at the end of the experiment.

	controls	HG-1	HG-2
Tb.Th (μm)	125 ± 0.7	118 ± 1.4 *	125 ± 1.5
BS/BV (1/mm)	16.1 ± 0.14	16.9 ± 0.14 *	15.9 ± 0.21
anisotropy	1.32 ± 0.01 *	1.28 ± 0.01	1.26 ± 0.01
D_{FH} (mm)	4.20 ± 0.13	3.92 ± 0.10	4.04 ± 0.16
D_{FN} (mm)	2.60 ± 0.17	2.42 ± 0.07	2.42 ± 0.20

*Table 1: Morphological parameters for the three experimental groups (mean±SD). * $p<0.05$ compared to the other groups.*

References 1) Gordon et al., Bone, 303-12, 1989.; 2) Keil et al., Physiol, 553-4, 1979; 3) Kimura et al., J Biomech, 361-5, 1979; 4) Wunder et al., Aviat Space Environ Med, 339-46, 1977; 5) Wunder, Aviat Space Environ Med, 1023-25, 1977.

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