BONE METABOLISM DURING STRICT HEAD-DOWN TILT BED REST WITH AND WITHOUT CO_2 EXPOSURE

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INTRODUCTION: Spaceflight and spacecraft have many negative physiological effects on the human body. One such factor is the exposure to elevated levels of carbon dioxide (CO_2). In fact, the CO_2 levels on board the International Space Station (ISS) have often reached levels 10x higher than outdoor terrestrial levels (1). Among other effects of CO_2, it is possible that this exposure alters bone metabolism, leading to an increase of bone tissue resorption and mineral efflux, thus jeopardizing bone fidelity and mission success. Bed rest is a common analog to simulate the effects of microgravity on bone as subjects are placed at a -6° head-down tilt (HDT) position which reduces the mechanical load on bone (2).

METHODS: Data are reported from two ground-based studies. These included a total of 12 male and 7 female subjects who were placed in a strict -6° HDT position for either 30 days at 0.5% ambient CO_2 or 60 days with nominal environmental exposure (0.04%). The term “strict” refers to the fact that subjects were not afforded a pillow and were not allowed to get up on an elbow while eating, thus increasing the headward fluid pressure. Bone mineral density (BMD) and bone mineral content (BMC) were determined using dual-energy X-ray absorptiometry (DXA). Blood and urine were collected before and during HDT for biochemical analysis. The data reported here were obtained from the NASA Standard Measures project.

RESULTS: There was no change in either BMD or BMC, which was expected given the short duration of these studies. Urinary excretion of collagen crosslink markers of bone resorption increased during HDT ($p < 0.001$), with no additive effect of CO_2. Serum and urine mineral concentrations were also not affected by CO_2. Serum PTH and 1,25-deoxyhydroxyvitamin D were both reduced during bed rest ($p < 0.0001$), but were not affected by CO_2.

DISCUSSION: Exposure to 0.5% CO_2 for 30 days did not exacerbate bone mineral or tissue loss during strict HDT bed rest. Additionally, these data document similar effects of strict HDT on bone and calcium metabolism as traditional HDT bed rest studies. The decrease in PTH and active vitamin D was likely secondary to calcium efflux from bone and, although not attributable to CO_2 exposure, reinforce the impact of bed rest and decreased mechanical loading on calcium and bone homeostasis. There was no evidence of the activation of the adrenal mechanism of bone loss due to CO_2 exposure alone. Future research on bone metabolism at other CO_2 levels is needed to better clarify a risk ceiling, especially as missions progress beyond low-earth orbit.

REFERENCES

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