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Treatment of hydrogen molecule abates oxidative stress and alleviates bone loss induced by modeled microgravity in rats

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Abstract

Treatment with molecular hydrogen alleviates microgravity-induced bone loss through abating oxidative stress, restoring osteoblastic differentiation, and suppressing osteoclast differentiation and osteoclastogenesis.

Introduction: Recently, it has been suggested that hydrogen gas exerts a therapeutic antioxidant activity by selectively reducing cytotoxic reactive oxygen species (ROS). The aim of the present study was to elucidate whether treatment with molecular hydrogen alleviated bone loss induced by modeled microgravity in rats.

Methods: Hindlimb suspension (HLS) and rotary wall vessel bioreactor were used to model microgravity in vivo and in vitro, respectively. Sprague-Dawley rats were exposed to HLS for 6 weeks to induced bone loss and simultaneously administrated with hydrogen water (HW). Then, we investigated the effects of incubation with hydrogen-rich medium (HRM) on MC3T3-E1 and RAW264.7 cells exposed to modeled microgravity.

Results: Treatment with HW alleviated HLS-induced reduction of bone mineral density, ultimate load, stiffness, and energy in femur and lumbar vertebra. Treatment with HW alleviated HLS-induced augmentation of malondialdehyde content and peroxynitrite content and reduction of total sulfhydryl content in femur and lumbar vertebra. In cultured MC3T3-E1 cells, incubation with HRM inhibited modeled microgravity-induced ROS formation, reduction of osteoblastic differentiation, increase of ratio of receptor activator of nuclear factor kappa B ligand to osteoprotegerin, inducible nitric oxide synthetase upregulation, and Erk1/2 phosphorylation. In cultured RAW264.7, incubation with HRM aggravated modeled microgravity-induced ROS formation, osteoclastic differentiation, and osteoclastogenesis.

Conclusion: Treatment with molecular hydrogen alleviates microgravity-induced bone loss in rats. Molecular hydrogen could thus be envisaged as a nutritional countermeasure for spaceflight but remains to be tested in humans.

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