Modeling of Blood Lead Levels in Astronauts Exposed to Microgravity-Accelerated Bone Loss

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Abstract: Human exposure to lead has been associated with multiple toxicologic endpoints. Studies of astronauts to space flight and their health risks incude an assessment of bone mineral density and the association of blood lead level with bone turnover markers. The bone loss observed for an average American astronaut during a long-duration mission is approximately 5% of total body bone mineral, which is similar to the normal rate of bone loss in older adults. Lead is a strong inhibitor of osteoblast activity and a stimulator of osteoclast activity, so a model was developed using a physiologically based pharmacokinetic (PBPK) approach. The PBPK model incorporates both environmental lead exposure and bone turnover for the prediction of blood lead levels in microgravity conditions. This work had the following purposes: (1) to develop a PBPK model of lead exposure and blood lead levels; (2) to compare model predictions for in-flight blood lead levels to data from actual missions; and (3) to determine the effect of lead exposure on the bone retention rate. The PBPK model was validated using data from a 365-day microgravity mission, and the results show that the model is effective for predicting blood lead levels in astronauts. The model also shows that the in-flight blood lead level is lower than the pre-launch level, which is consistent with the observed data. Therefore, the PBPK model can be used to predict blood lead levels in astronauts and to evaluate the effects of lead exposure on bone health.