Prevention of spaceflight-induced bone loss: A promising dietary countermeasure

Ann-Sofie Schreurs (USRA, ann-sofie.schreurs@nasa.gov), Candice G. G. Tahimic (Wyle, candiceginn.t.tahimic@nasa.gov), Sonette Steczina (Blue Marble, sonette.steczina@nasa.gov); , Moniece Lowe (Blue Marble, moniece.lowe@nasa.gov), Joshua S. Alwood (NASA ARC, joshua.s.alwood@nasa.gov), Ruth K. Globus (NASA ARC, ruth.k.globus@nasa.gov)

Space radiation is one of the challenges for long-term spaceflight, especially for missions beyond low Earth Orbit. We have shown that a diet composed of 25% dried plum (DP) prevents radiation-induced bone loss. The DP diet fully protected the cancellous bone microarchitecture of mice exposed to ionizing radiation (gamma, proton, and HZE). In particular relevant to space radiation, we showed that the DP diet prevents bone loss due to 1Gy of sequential exposure of proton (1H, low linear energy transfer –LET-), and 1Gy of iron (56Fe, high-LET). In addition, total body exposure to 1Gy of HZE radiation (56Fe) impaired the osteoprogenitors in mice fed the control diet, as indicated by decreased osteoblast mineralization. In contrast, marrow stem cells from mice fed the DP did not exhibit these deficits. Based on these promising results supporting DP as a countermeasure to prevent space radiation induced-tissue damage, we conducted additional studies to combine radiation and simulated microgravity. We exposed skeletally mature male mice to simulated microgravity (using hindlimb unloading, HU) or total body irradiation (TBI, 2Gy 137Cs) or in combination (HU+TBI). We observed bone loss in the mice fed the control diet (CD) exposed to simulated spaceflight, as measured by cancellous bone microarchitecture parameters such as percent bone volume (BV/TV). In contrast, mice fed the DP diet did not exhibit similar bone loss with either treatments (HU or TBI) or combined (HU+TBI) as seen in most parameters. This was observed in both long bones (tibia) and axial bones (vertebrae). Furthermore, preliminary data shows that pre-feeding with the DP diet attenuates the HU-induced decrement in bone-forming osteoblasts colony counts and mineralization capacity of the osteoprogenitor cells. We also performed DP feeding at lower doses (5%, 10%) and found that these doses are less effective in preventing the radiation-induced bone loss. All our studies with the DP diet as a countermeasure were done with a period of pre-feeding ranging from 14 to 21 days before irradiation, and in order to test the capacity of the DP diet as a countermeasure provided after exposure to radiation, we exposed mice to 2Gy gamma radiation and then provided the DP diet 24 hours post-IR. Preliminary data indicates that DP mitigated the radiation-induced deficits in certain cancellous bone structural parameters. Finally, we showed that mice fed with the control diet (CD) increased oxidative damage in the serum after radiation exposure, whereas mice fed the DP diet do did not show such an increase. In summary, the DP diet is a promising countermeasure for spaceflight-induced tissue damage.