Rodents sent to the ISS reveal possible links between gut bacteria and bone loss in microgravity

April 19 2023

An illustration of a rodent wearing a space helmet. Credit: Liana Wait

The bone density of astronauts—of both the human and rodent variety—decreases in space. Researchers report on April 19 in the journal *Cell Reports* that changes to the gut microbiomes of space travelers might be associated with this bone loss. Rodents that spent a month or more on the International Space Station had altered and more diverse microbiomes, and the bacterial species that bloomed in space may have contributed to the increased production of molecules that are known to influence the bone remodeling process.

"This is just another vivid example showing the dynamic interactions between the microbiome and mammalian hosts. The gut microbiome is constantly monitoring and reacting, and that's also the case when you're exposed to microgravity," says senior author Wenyuan Shi, a microbiologist and chief executive officer at the Forsyth Institute. "We've yet to find out whether there's a causal link between changes to the microbiome and the observed bone loss in microgravity and if it is simply a consequence or an active compensation to mitigate, but the data are encouraging and create new avenues for exploration."

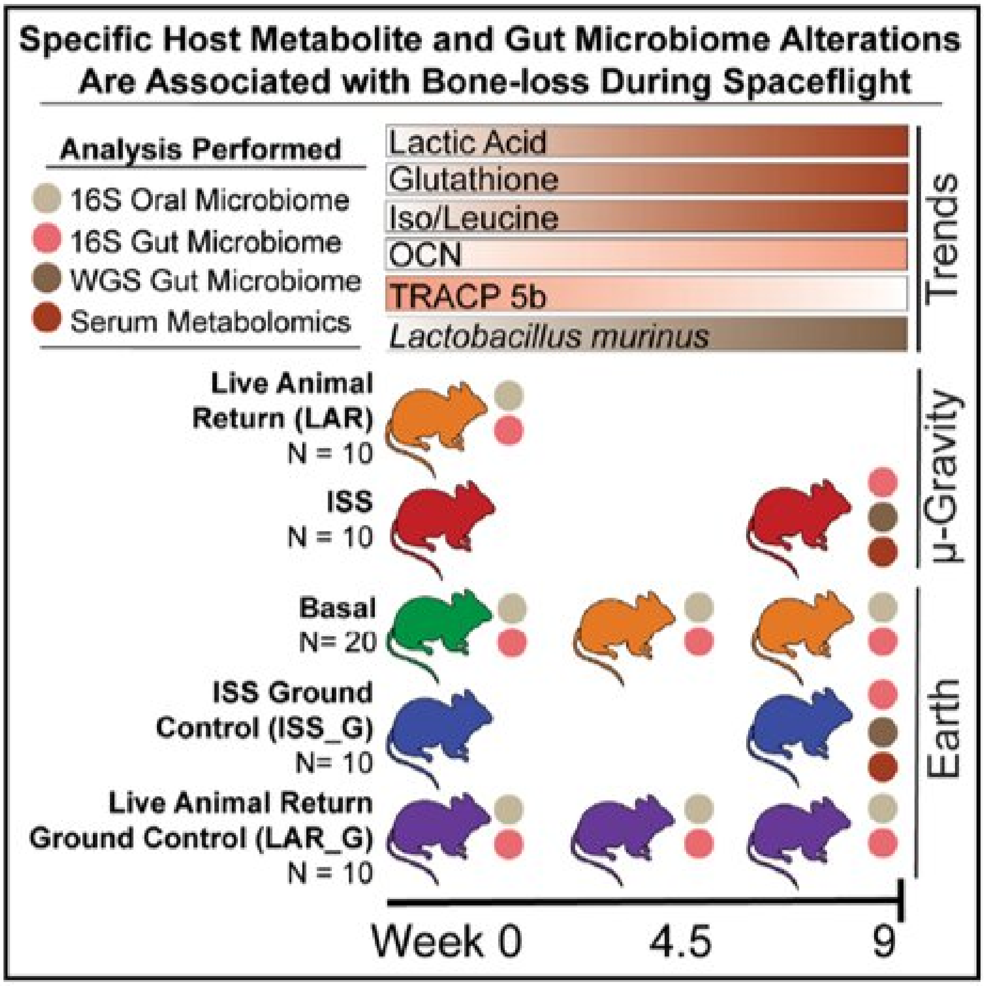
Our bones aren't static; even when we're fully grown, material is constantly being added, removed, and shifted around in a process called bone remodeling. Recent studies have suggested that gut microbes might impact bone remodeling via various mechanisms including interactions with the immune and hormonal systems. Microbes also produce various molecules because of their own metabolism, and some of these metabolites interact indirectly with the cells responsible for bone remodeling.

We'd expect the microbiome to be impacted by space travel for several reasons. "First and foremost, there are the physical forces at play, such as microgravity and cosmic radiation exposure, which affect not only the bacterial cells but also the human cells," says first author and microbiologist Joseph K. Bedree, who began the work while at UCLA and continued it at the Forsyth Institute. "Likewise, there are numerous resulting effects on host biological systems from microgravity exposure—immune system irregularities, musculoskeletal changes, altered circadian rhythm, stress—and when those systems become imbalanced, the microbial communities potentially could be disrupted, too."

To explore how the microbiome changes during prolonged exposure to microgravity, and to investigate possible links between these changes and bone density, the researchers sent 20 rodents to the International Space Station. Ten of these rodents returned alive to Earth after 4.5 weeks, and the researchers tracked how their microbiomes recovered upon return. The remaining 10 space rodents remained in orbit for a total of nine weeks. Twenty "ground control" rodents were housed in identical conditions—although minus the microgravity—on Earth. The team characterized and compared the microbial communities for the different groups over time: before launch off, after return to Earth, and at end of the study. They also evaluated changes in serum metabolites for the space rodents that were exposed to microgravity for the full nine weeks.

"This is the first time in NASA history that a rodent has been returned to Earth alive," says Shi. "This meant we were able to gather information about the change in space, and then monitor their microbiome's recovery when they returned. The good news is that even though the microbiome changes in space, these alterations don't appear to persist upon returning to Earth."

When the team characterized and compared the gut microbiomes of the space and ground control rodents, they found that the space rodents had more diverse gut microbiomes. Two types of bacteria—Lactobacillus and Dorea species—were much more abundant in rodents that were exposed microgravity, and their abundance was even higher in rodents that were in space for 9 weeks versus 4.5 weeks. The metabolism of these two bacteria also could have contributed to the elevated metabolites that were detected and associated with microgravity exposure.



A graphical abstract depicting how specific host metabolite and gut microbiome alterations are associated with bone loss during spaceflight. Credit: Bedree et al

"When we mapped the genetic pathways for Lactobacillus and Dorea, they seemed to line up with the metabolites that were elevated during microgravity exposure," says Bedree. "When someone's in microgravity and experiencing bone loss, it would make sense that their body would try to compensate and that the biological systems within would be doing that as well, but we need to do more mechanistic studies to truly validate these hypotheses."

One non-microgravity factor that may have influenced the rodents' changing microbiome in space is the fact that they were not able to engage in coprophagy, a normal rodent behavior whereby they eat their own feces, which reintroduces microbes back into the gut. However, the rodents that returned from space after 4.5 weeks were able to engage in coprophagy upon return, and this probably contributed to their microbiomes' recovery.

While this study sheds light on how the microbiome changes during space travel, the authors say that more work needs to be done to understand the possible link between the microbiome and bone density. They plan to continue the research here on Earth.

If we can figure out which microbes support the maintenance of bone density, it could help astronauts stay healthier in space. The researchers say this information could also help people back on Earth who suffer bone loss from non-gravity-related reasons. "This could potentially lead to new tools for managing diseases like osteopenia or osteoporosis, so it's not just an isolated story in space," says Shi.

More information: Joseph K. Bedree et al, Specific Host Metabolite and Gut Microbiome Alterations Are Associated with Bone-loss During Spaceflight, *Cell Reports* (2023). DOI: 10.1016/j.celrep.2023.112299. www.cell.com/cell-reports/full … 2211-1247(23)00310-8

Provided by Cell Press

microgravity (2023, April 19) retrieved 24 April 2024 from
https://phys.org/news/2023-04-rodents-iss-reveal-links-gut.html