

Summary of: Characterization of the total and viable bacterial and fungal communities associated with the International Space Station surfaces

Key findings:

1. **Total and Viable Microbial Communities**: - **Total Microbial Load**: The cultivable bacterial and fungal populations ranged from 10^4 to 10^9 CFU/m², depending on location. - **Viable Microbial Load**: The average number of viable bacteria and fungi ranged from 10^4 to 10^9 CFU/m².
2. **Temporal Distribution**: - **Temporal Changes**: The bacterial load fluctuated across locations, but no significant differences were observed between flights. - **Temporal Changes**: The fungal load fluctuated across locations, but no significant differences were observed between flights.
3. **Spatial Distribution**: - **Spatial Changes**: The bacterial load varied across locations, but no significant differences were observed between flights. - **Spatial Changes**: The fungal load varied across locations, but no significant differences were observed between flights.
4. **Community Composition**: - **Bacterial Community**: The bacterial community composition changed over time, but not across locations. - **Fungal Community**: The fungal community remained the same between samplings and locations.
5. **Viable vs. Dead Cells**: - **Viable Cells**: Approximately 46% of the viable bacteria and 40% of the viable fungi could be cultured. - **Dead Cells**: The remaining 54% of viable bacteria and 60% of viable fungi were dead cells.
6. **Comparison with Culture-Based Methods**: - **Similarity**: Both methods identified similar numbers of fungal phyla. - **Quantitative Differences**: The bacterial load was higher than the fungal load by 2 to 3 logs at all locations.
7. **Microbial Diversity**: - **Total Diversity**: The total bacterial and fungal diversity was high, with 68 different families detected. - **Alpha Diversity**: The alpha diversity (measured with Shannon's diversity index) was high, with Shannon's diversity index indicating high diversity.
8. **Microbial Load**: - **Total Load**: The total bacterial and fungal loads ranged from 6.7×10^3 to 7.8×10^{10} CFU/m². - **Fungal Load**: The fungal load ranged from 1.1×10^5 to 3.1×10^8 CFU/m².
9. **Antimicrobial Resistance**: - **Antimicrobial Resistance**: The presence of opportunistic pathogens was noted, including *Staphylococcus aureus*, *Klebsiella quasipneumoniae*, and *Aspergillus fumigatus*.

10. **Comparison with Earth Microbiomes**: - **Similarity**: The ISS microbiome shares similarities with indoor microbiomes, particularly those in hospitals, offices, and classrooms. - **Differences**: The ISS microbiome is more similar to indoor microbiomes than to outdoor microbiomes.

11. **Implications**: - **Health Risks**: The presence of opportunistic pathogens highlights the need for safety measures to prevent infections. - **Long-term Space Missions**: The ISS microbiome provides insights for long-term space habitation, including countermeasures to reduce microbial spread.

12. **Sample Collection**: - **Sampling Locations**: The ISS was sampled at eight locations, including the US module, PMM, and PMM port 1. - **Sampling Frequency**: Samples were collected over a period of 14 months, with three flight sampling sessions.

13. **Data Processing**: - **DNA Extraction**: DNA extraction was performed using the Maxwell 16 automated system. - **PCR Amplification**: qPCR was used to quantify microbial abundance. - **Amplicon Sequencing**: 16S rRNA gene and ITS region were targeted for amplicon sequencing.

14. **Statistical Analysis**: - **PMA Treatment**: PMA was used to distinguish between viable and dead cells. - **Statistical Tests**: Kruskal-Wallis test was used to compare groups, with Dunn's post-hoc test for significance.

15. **Comparison with Other Studies**: - **Comparison with Other ISS Studies**: The ISS microbiome was compared to other closed environments, particularly hospital settings. - **Comparison with Other Clean Rooms**: The ISS microbiome was compared to spacecraft assembly cleanrooms.

16. **Future Research**: - **Long-term Studies**: Future studies should include longer-term studies to assess microbial persistence. - **Spacecraft Assembly Cleanrooms**: Studies should be conducted in spacecraft assembly cleanrooms to understand microbial dynamics.

17. **Conclusion**: - **Health Risks**: The ISS microbiome poses health risks to astronauts, particularly to those with compromised immune systems. - **Safety Measures**: The ISS