Defense Health Agency (DHA) Clinical Communities Speaker Series

Healthcare Innovation and Readiness: Empowering Change and Resilience in Global Care Delivery

2025 SEP CCSS S04: Integrated Human Performance: Delivering Care and Capability in Constrained Environments

Resource List

Effects of Exercise Countermeasures on Multisystem Function in Long Duration Spaceflight Astronauts (2023) evaluated the effectiveness of exercise countermeasures in preventing multisystem deconditioning in astronauts during long-duration spaceflights. While astronauts performed approximately 600 minutes of combined aerobic and resistance exercise per week, the study found that this exercise regimen did not fully protect against deconditioning. Furthermore, the response to exercise varied significantly among individuals (ranging from -30% to +5% change from pre- to post-flight), suggesting that up to 17% of astronauts could experience performance-limiting deconditioning under the current exercise protocols. The findings highlight the need for improved countermeasures, additional interventions, and/or more stringent pre-flight physical requirements to safeguard astronaut health and performance on future lunar and deep space missions.

The Effects of Spaceflight Microgravity on the Musculoskeletal System of Humans and Animals, with an Emphasis on Exercise as a Countermeasure: A Systematic Scoping Review (2021) examined the impact of microgravity on the musculoskeletal system (both bones and muscles) in humans and animals. It also investigated the effectiveness of exercise as a countermeasure, focusing on human studies. The review analyzed 84 publications (40 animal studies and 44 human studies) identified through a search of PubMed, Embase, Scopus, and Web of Science. Due to variations in study designs, a meta-analysis was not possible. Instead, the review provides a narrative synthesis of findings across five key areas: muscle response to microgravity in humans and animals, bone response to microgravity in humans and animals, and the effectiveness of exercise countermeasures on the human musculoskeletal system in microgravity. The study followed established guidelines for scoping reviews and systematic reviews.

Neck Muscle Changes Following Long-Duration Spaceflight (2019) documents the investigation of the impact of long-duration spaceflight on neck muscle size and fat content in astronauts using MRI before and after missions with advanced resistive exercise. Results showed that while most neck muscles maintained their size, the trapezius, semispinalis capitis, sternocleidomastoid, and rhomboid minor muscles significantly increased in size after spaceflight, suggesting that the cervical muscles may not be as susceptible to the degradative effects of microgravity as other muscles in the body. There were no significant changes in muscle fat infiltration observed.

Following a six-month mission on the International Space Station (2017), a 38-year-old European Space Agency astronaut experienced postflight physical performance impairments despite adhering to a rigorous daily in-flight exercise program. Assessments of muscle strength, power, core endurance, and hip flexibility revealed deficits at six days post-landing, with most parameters recovering by day 21, except for muscular power demonstrated in jump tests. A 21-day postflight reconditioning program, focused on motor control and functional training delivered by European Space Agency specialists, facilitated the recovery. The study highlights the persistent negative effects of microgravity, even with intensive countermeasures, suggesting that complex, power-based tasks require more time to return to preflight levels and underscoring the need for further research to optimize both in-flight and post-flight exercise programs for faster astronaut reconditioning.

References

McNamara, K.P., Green, K.A., Tooze, J.A., Dang, J., Khattab, K., Lenchik, L. & Weaver, A.A. (2019). Neck Muscle Changes Following Long-Duration Spaceflight. S*ec. Environmental, Aviation and Space Physiology*, 10. https://doi.org/10.3389/fphys.2019.01115

Moosavi, D., Wolovsky, D., Depompeis, A., Uher, D., Lennington, D., Bodden, R., & Garber, C. E. (2021). The Effects of Spaceflight Microgravity on the Musculoskeletal System of Humans and Animals, with an Emphasis on Exercise as a Countermeasure: A Systematic Scoping Review. *Physiological research*, 70(2), 119–151. https://doi.org/10.33549/physiolres.934550

Petersen, N., Lambrecht, G., Scott, J., Hirsch, N., Stokes, M., & Mester, J. (2017). Postflight Reconditioning for European Astronauts - A Case Report of Recovery after Six Months in Space. *Musculoskeletal science & practice*, 27 Suppl 1, S23–S31. https://doi.org/10.1016/j.msksp.2016.12.010

Scott, J. M., Feiveson, A. H., English, K. L., Spector, E. R., Sibonga, J. D., Dillon, E. L., Ploutz-Snyder, L., & Everett, M. E. (2023). Effects of Exercise Countermeasures on Multisystem Function in Long Duration Spaceflight Astronauts. *NPJ microgravity*, 9(1), 11. https://doi.org/10.1038/s41526-023-00256-5