The impact of variable gravitation on muscle–tendon interaction and function

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Since Yuri Gagarin's pioneering flight in 1961, numerous missions of varying length and on a range of platforms have explored space and its effects on the human body. To maximize the benefits of future Mars and moon missions, extravehicular activities in low-gravity environments will be essential during human exploration. In sustained missions (Artemis 2), crewmembers are required to move from a defective rover to a safe location over distances of up to 12 km. A simple fall due to muscle weakness or lack of locomotor control could result in injuries or spacesuit damage that could be life-threatening. Ultrasonic visualization of muscle fascicle and tendon (SEE) behavior during locomotion has demonstrated the importance of the storage and release of elastic energy by the Achilles tendon in running and walking, and that the plantar flexor muscles modulate their behavior depending on gait type, speed, and external loading. Despite the relevance of this topic to both space travel and rehabilitation, only a few studies have examined the behavior of muscles and tendons in simulated or real hypergravity. The shorter peak SEE length observed during running in simulated 0.7 g may be the result of lower muscular forces acting on the SEE (Richter et al., 2021a). The longer fascicles observed during running in simulated (0.7 g) hypogravity may result in an increased strain on the z-disks, which in turn may be beneficial for muscle mass preservation. Decreasing g-level from 1 g to simulated Martian and lunar gravity resulted in hypogravity-induced alterations in SEE length, and contractile behavior that persisted between simulated running on the moon and Mars (Richter et al., 2021b). This should be taken into account when evaluating exercise prescriptions and the transferability of locomotion practiced in lunar gravity to Martian gravity. Monti et al. (2021) assessed fascicle behavior during the locomotor-like task—drop jump—during a parabolic flight. Upon landing, gastrocnemius medialis fascicles showed lengthening in all gravity levels below and above 1 g and quasi-isometric fascicle behavior in 1 g. Such behavior was potentially due to the lower level of muscle pre-activation (Waldvogel et al., 2021), implying a modulation of the muscle's mode of operation toward a damping function. Thus, existing studies have demonstrated that the consequences of locomotion in hypogravity are not limited to a mere reduction in mechanical loading but also to an altered contractile behavior, which could affect the muscle's work capacity upon return to daily activities in a 1 g environment and may require specific attention for adequate countermeasures and during the rehabilitation phase.

Monti, E., et al. (2021). Frontiers in Physiology, 12, 714655. Richter, C., et al. (2021a)
Npj Microgravity, 7(1), 1–8. Richter, C., et al. (2021b)
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