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MYOTONES — INFLIGHT MUSCLE HEALTH STATUS MONITORING DURING LONG-DURATION SPACE MISSIONS ONBOARD THE INTERNATIONAL SPACE STATION: A SINGLE CASE STUDY

Abstract

The MYOTONES experiment is the first to monitor changes in the basic biomechanical properties (tone, elasticity and stiffness) of the resting human myofascial system due to microgravity with a non-invasive, portable device on board the ISS. The MyotonPRO device applies several brief mechanical stimuli to the surface of the skin, and the natural oscillation signals of the tissue beneath are detected and computed by the MyotonPRO. Thus, an objective, quick and easy determination of the state of the underlying tissue is possible.

Two preflight, four inflight and four post flight measurements were performed on a male astronaut using the same 10 measurement points (MP) for each session. MPs were located on the plantar fascia, Achilles tendon, M. soleus, M. gastrocnemius, M. multifidus, M. splenius capitis, M. deltoideus anterior, M. rectus femoris, infrapatellar tendon, M. tibialis anterior. Subcutaneous tissues thickness above the MPs was measured using ultrasound imaging. Magnetic resonance images (MRI) of lower limb muscles and functional tests were also performed pre- and postflight.

Our first measurements on board the ISS confirmed increased tone and stiffness of the lumbar multifidus muscle, an important trunk stabilizer, dysfunction of which is known to be associated with back pain. Furthermore, reduced tone and stiffness of Achilles tendon and plantar fascia were observed inflight vs. preflight, confirming previous findings from terrestrial analog studies and parabolic flights. Unexpectedly, the deltoid showed negative inflight changes in tone and stiffness, and increased elasticity, suggesting

a potential risk of muscle atrophy in longer spaceflight that should be addressed by adequate inflight countermeasure protocols. Most values from limb and back MPS showed deflected patterns (in either directions) from inflight shortly after the re-entry phase on the landing day and one week later. Most parameter values then normalized to baseline after 3 weeks likely due to 1G re-adaptation and possible outcome of the reconditioning protocol. No major changes in subcutaneous tissues thickness above the MPs were found inflight vs preflight, suggesting no bias (i.e., fluid shift, extreme tissue thickening or loss). Pre- and postflight MRI and functional tests showed negligible changes in calf muscle size, power and force, which is likely due to training effects from current inflight exercise protocols.

The MYOTONES experiment is currently ongoing to collect data from further crew members. The potential impact of this research is to better understand the effects of microgravity and countermeasures over the time course of an ISS mission cycle. This will enable exercise countermeasures to be tailored more specifically and efficiently for the individual astronaut to maintain their musculoskeletal health.