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ESTIMATING IN-VIVO VISCOELASTIC PROPERTIES OF SKELETAL MUSCLE FROM THEIR NATURAL VIBRATIONS

Abstract

Monitoring mechanical properties of skeletal muscles is essential for assessing and maintaining the musculoskeletal health of astronauts. Spaceflight is likely to reduce muscle stiffness (i.e. elasticity) based on the findings from an unloading model in a rat hindlimb muscle (Toursel et al. 2002). A reduction in muscle stiffness after returning to earth is also likely because an unloaded muscle is susceptible to injuries with eccentric contractions during reloading (Thompson et al. 1999). However, changes in viscoelastic properties of skeletal muscle with human spaceflight are unknown due to the absence of a feasible technique. To quantify the local viscoelastic properties of skeletal muscle, a non-invasive, passive, in-vivo elastography technique for contracting muscles was designed and investigated. During muscle contractions, low frequency (< 100 Hz) and continuous surface mechanical oscillations, also called muscle noise, naturally occur due to the cyclic shortening-lengthening of the actomyosin filaments along the muscle fiber axis. Recordings of this muscle noise are called surface mechanomyograms. By measuring skeletal muscle noise of the biceps brachii during static voluntary contractions, the local propagation velocity of mechanical shear vibrations were quantified. A 3 x 5 grid of miniature accelerometers was placed on the biceps brachii of ten male subjects to measure the naturally occurring vibrations. From this data, the local propagation velocity was calculated as an index of muscle stiffness using cross correlation and beam forming techniques. With this method, each passive sensor becomes a virtual in-vivo shear wave source. Preliminary results showed that changes in local propagation velocity corresponded to the expected changes in muscle stiffness during muscle contractions at different levels. The results point to a low-cost, portable and non-invasive technique for monitoring biomechanical in-vivo muscle properties. The applicability of this technique for monitoring muscle properties in astronauts during and after long space missions will be discussed.