# Pressurized Device for Mitigating Atrophy in Soleus During Long-Duration Spaceflight

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ABSTRACT

A major concern with long duration spaceflight, skeletal muscle atrophy is most detrimental in lower limb musculature, particularly in muscles critical for proper gait, such as the soleus. The decline of muscle activation and the suppression of sensory input from plantar sole mechanoreceptors can add to the attenuation of skeletal muscle health during spaceflight. More specifically, inhibition of sensory input from sole receptors, such as with gravitational unloading, decreases selective activation, thereby negatively affecting muscle tone and inevitably resulting in lower limb atrophy. **PURPOSE**: To design, fabricate, and test a specialized boot with an insole that applies oscillating pneumatic pressure for set periods of time to augment neuromuscular activation of the soleus through the plantar sole's mechanoreceptors, which may minimize atrophy of lower extremity muscles. **METHODS**: The custom boot was originally designed in three-dimensional modeling software (Solidworks Premium, Waltham, MA). Components of the boot included: a lightweight medical walking brace, Metro-ATmega circuit board, air pump and vacuum DC motor, force resistive sensor, and kPa sensor. The boot was programmed using C++ to allow the user to wear the boot for 20 minutes (oscillating continuously) at the start of every hour with an automatic timer for 6 hours per day. Surface electromyography (EMG) measured electrical activity in lower extremity muscles while wearing the boot. The location of all electrodes were determined according to the SENIAM project (Surface Electromyography for the Non-Invasive Assessment of Muscles): 1) for soleus, electrode placed at two-thirds of the line between the medial condyle of the femur to the medial malleolus; 2) for medial head of the gastrocnemius, electrode placed at one-third of the line between the head of the fibula and the heel; 3) for ground, electrode placed at the tibial tuberosity. Muscle activation of the gastrocnemius was measured to investigate any co-activation of nearby musculature on the posterior leg. **RESULTS**: Upon airbag inflation, the soleus exhibited the greatest amplitude (30 to 50 μV versus 5 to 15 μV) when the ankle attempted to plantarflex while maintaining a neutral position. When the airbags are inflated, the pressure output corresponds to approximately 111 kPa. When the airbags are deflated, the pressure output corresponds to approximately 66 kPa, creating a pressure difference of 45 kPa. During the 20 min runtime, the airbags take 3.3 sec to inflate and 3.0 sec to deflate, creating the oscillating effect. When fully charged, the battery can sustain one full, 6-hour session with each lasting 20 minutes. **CONCLUSION**: Pneumatic pressure integrated into a customized therapeutic walking boot may elicit neuromuscular activity in the lower extremity musculature, which indicates that the device may help in attenuating the negative neuromuscular adaptations in the soleus via afferent signaling.