

Mechanical Foot Stimulation Results in Lower Limb Muscle Activation

by Charles S. Layne

THE AIM OF INVESTIGATION IN 2005 WAS to determine the modulating effect of background muscle activity on enhanced neuromuscular responses to mechanical foot stimulation. A small solenoid embedded within a platform provided non-noxious stimulation to the lateral portion of the sole for 100ms at 3mm protrusion. Stimulation was applied during different contraction levels of the homonymous muscle and of remote, Jendrassik-like contractions. We measured root mean square electromyography from the soleus and lateral gastrocnemius. Homonymous muscle contraction linearly increased the neuromuscular response to foot stimulation, although no effect was exhibited from remote contractions. The levels of response to stimulation in all conditions were 80-100 percent of maximal contraction levels. The application of mechanical foot stimulation can be used to elicit and enhance neuromuscular activity of the triceps surae muscles, particularly when combined with preexisting "background" voluntary contractions. This activity could be used to attenuate neuromuscular degradation experienced during prolonged bedrest and during extended stays in microgravity.

Publications

- Forth, K.E. and Layne, C.S. "The Influence of Loading and Postural Context on the Neuromuscular Response to Mechanical Foot Stimulation." (*Under review*)
- Forth, K.E., and Layne, C.S. "Background Muscle Activity Enhances the Neuromuscular Response to Mechanical Foot Stimulation," *American J. of Physical Medicine & Rehabilitation*, 86 (2006): 50-56.

Presentations

- Forth, K. E. and C. S. Layne. "The Neuromuscular Response to Context-Specific Foot Stimulation," The Houston Society for Engineering in Medicine and Biology, The 22nd Annual Houston Conf. on Biomedical Engineering Research, Feb., 2005.
- Forth, K. E. and C. S. Layne. "Spatial and Temporal Mechanical Foot Stimulation Parameters Influence Neuromuscular Responses in the Lower Limbs," Sigma Xi Student Research Day, University of Houston, April, 2004.
- Layne, C. S., K. T. Nguyen, and K. E. Forth. "Muscle Contractions in Response to Foot Stimulation as an Inflight Countermeasure," 16th Humans in Space Symposium of the Intl. Academy of Astronautics (IAA), May, 2007.
- Layne, C. S. "Budget Crunches and the Future: The Need for

Strategic Planning," Texas Association for Health, Physical Education, Recreation, and Dance (TAHPERD), Galveston, TX, Dec., 2003.

Layne, C. S., A. P. Mulavara, J. J. Bloomberg, K. E. Forth, M. F. Baxter, J. J. Houser, I. B. Kozlovskaya. "Using Dynamic Foot Stimulation During Space Flight as a Countermeasure to Muscle Degradation," 24th Annual Intl. Conf. of the IEEE/EMBS (Institute of Electrical and Electronics Engineers,



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Inc. and Engineering in Medicine and Biology and Annual Fall Meeting of the BMES (Biomedical Engineering Society), Houston, TX, Oct., 2002. (*Invited.*)

Layne, C. S., K. E. Forth, and A. F. Abercromby. "Spatial Factors Influence the Generation of Neuromuscular Responses to Foot Stimulation," 14th Humans in Space Conf., Banff, Alberta, Canada, May, 2003.

Layne, C. S., K. T. Nguyen, and K. E. Forth. "Muscle Contractions in Response to Foot Stimulation as an Inflight Countermeasure," 16th Humans in Space Symposium of the Intl. Academy of Astronautics (IAA), May, 2007.

Nguyen, K. T. and Layne, C. S. "Identifying Neuromuscular Inhibition in the Human Lower Leg Using Mechanical Stimulation to the Foot," The Houston Society for Engineering in Medicine and Biology, The 22nd Annual Houston Conf. on Biomedical Engineering Research, Feb., 2005. "Runner up" award: one out of four recognitions among 77 posters in Student Poster Competition.

Funding

- Layne, C. S. "Developmental Evaluation of a Dynamic Foot Stimulation Device," National Aeronautics and Space Administration (NASA), Jan., 2004. \$59,592 (*direct costs*). Contract modification, April 2004. \$20,000 added.
- Layne, C. S. "Using Patterned Stimulation of the Soles to Prevent Muscle Degradation," Faculty Research Opportunity Award (FROA), College of Education, University of Houston, Feb. 2003. \$2,835. (*Funded.*)

Student Researchers

During the previous reporting period, ISSO-supported student Katharine E. Forth, who earned her Ph.D. in Motor Control from the Department of Health and Human Performance, University of Houston. She is continuing in her role as a post-doctoral fellow in the Neurosciences Laboratory at the NASA-Johnson Space Center.

During the reporting period, Andrew Abercromby, who previously worked on the project, obtained his Ph.D. degree in Motor Control from the Department of Health and Human Performance, University of Houston. Dr. Abercromby is now employed by Wyle Life Sciences at NASA-JSC.

Ms. Kimthu Nguyen in 2005 earned her M.S. in the exercise science program in the Department of Health and Human Performance, University of Houston.