

# Researchers use 'Avatar' experiments to get leg up on locomotion

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Simple mechanical descriptions of the way people and animals walk, run, jump and hop liken whole leg behavior to a spring or pogo stick.

But until now, no one has mapped the body's complex physiology - which in [locomotion](#) includes multiple leg muscle-tendons crossing the hip, knee and ankle joints, the weight of a body, and control signals from the brain - with the rather simple physics of spring-like limb behavior.

Using an "Avatar"-like bio-robotic motor system that integrates a real muscle and tendon along with a computer controlled nerve stimulator acting as the avatar's spinal cord, North Carolina State University researchers have taken a giant leap closer to understanding locomotion from the leg up. The findings could help create robotic devices that begin to merge human and machine in order to assist human locomotion.

Despite the complicated physiology involved, NC State biomedical engineer Greg Sawicki and Temple University post-doctoral researcher Ben Robertson show that if you know the mass, the stiffness and the leverage of the ankle's primary muscle-tendon unit, you can predict neural control strategies that will result in spring-like behavior.

"We tried to build locomotion from the bottom up by starting with a single muscle-tendon unit, the basic power source for locomotion in all things that move," said Greg Sawicki, associate professor in the NC State and UNC-Chapel Hill Joint Department of Biomedical Engineering and co-author of a paper published in *Proceedings of the National*

*Academy of Sciences* that describes the work. "We connected that muscle-tendon unit to a motor inside a custom robotic interface designed to simulate what the muscle-tendon unit 'feels' inside the leg, and then electrically stimulated the muscle to get contractions going on the benchtop."

The researchers showed that resonance tuning is a likely mechanism behind springy leg behavior during locomotion. That is, the electrical system - in this case the body's nervous system - drives the mechanical system - the leg's muscle-tendon unit - at a frequency which provides maximum 'bang for the buck' in terms of efficient power output.

Sawicki likened resonance tuning to interacting with a slinky toy. "When you get it oscillating well, you hardly have to move your hand - it's the timing of the interaction forces that matters.

"In locomotion, resonance comes from tuning the interaction between the nervous system and the leg so they work together," Sawicki said. "It turns out that if I know the mass, leverage and stiffness of a muscle-tendon unit, I can tell you exactly how often I should stimulate it to get resonance in the form of spring-like, elastic behavior."

The findings have design implications relevant to designing exoskeletons for able-bodied individuals, as well as exoskeleton or prosthetic systems for people with mobility impairments.

"In the end, we found that the same simple underlying principles that govern resonance in simple mechanical systems also apply to these extraordinarily complicated physiological systems," said Robertson, the corresponding author of the paper.

**More information:** "Unconstrained muscle-tendon workloops indicate resonance tuning as a mechanism for elastic limb behavior during

terrestrial locomotion" online the week of Oct. 12, 2015, in *Proceedings of the National Academy of Sciences*, [DOI: 10.1073/pnas.1500702112](https://doi.org/10.1073/pnas.1500702112)

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