# Miniature treadmills accelerate studies of insects walking

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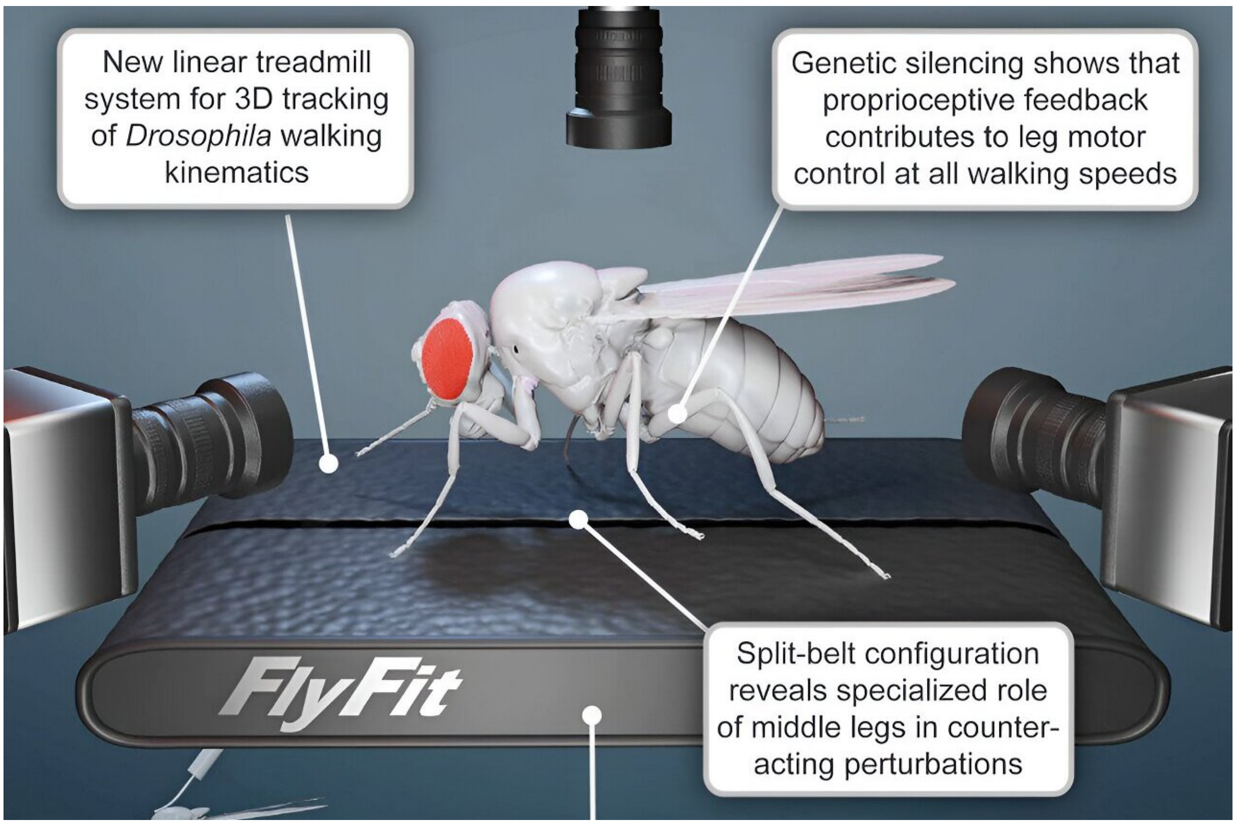


Graphical abstract. Credit: *Current Biology* (2024). DOI: 10.1016/j.cub.2024.08.006

Fruit flies walking on miniature treadmills are helping scientists learn how the nervous system enables animals to move in an unpredictable and complex world.

Insights from using these fruit fly-sized treadmills were reported Aug. 30 in Current Biology. Several videos of the flies running on the treadmills are available for viewing on the online research paper. The lead author is Brandon G. Pratt, a recent physiology and biophysics Ph.D. graduate of the University of Washington School of Medicine in Seattle and a National Science Foundation Graduate Research Fellow.

He engineered the small-scale machines from inexpensive parts, based on a prototype from Max Mauer, a UW mechanical engineering alumnus.

Pratt and his research colleagues explained that walking animals, including insects and people, must recognize and rapidly deal with unexpected changes underfoot. If an animal were unable to do so, navigating the world would be nearly impossible and injury from falls would be likely.

How does the nervous system detect these unexpected events and control the body to regain balance during locomotion? That question is being explored in John Tuthill's laboratory at the UW Department of Physiology and Biophysics, where Tuthill is an associate professor and Pratt conducted his doctoral research. Lab colleagues Su-Yee J. Lee and Grant M. Chou also contributed to this project.

Tuthill's lab studies proprioception: how the body continually senses its articulation and movement. Illness, injury, and other factors can interfere with the ability of people and animals to coordinate their bodies and hinder simple tasks like grabbing a glass of water or walking a couple of feet.

Investigating how proprioception controls the body when it becomes off kilter during locomotion is a fundamental challenge for neuroscientists. Experimental disruptions to proprioception can curb animal behaviors and thereby confound efforts to examine proprioception's role in natural activities like walking.

Historically, treadmills have effectively reignited animals' desire to walk after perturbations to the nervous system. Treadmills have helped to provide insight into the neural control of walking and running with invertebrates (animals without backbones) like cockroaches and stick insects, as well as vertebrates like rodents, cats, and humans.

Split-belt treadmills have two belts that move independently. Researchers use them to investigate how the coordination between the legs adapts when the legs on the left side of the body move at a different speed than those on the right. These treadmills have played a clinical role in evaluating stroke patients.

Both types of treadmill systems inspired researchers in the Tuthill lab to engineer miniature versions to study locomotion in fruit flies. These tiny creatures are a good model system to study the neural control of locomotion because they have a compact, fully mapped nervous system. Moreover, a suite of genetic tools enables scientists to perform precise and specific manipulations of the fly nervous system.

The linear treadmill system in Tuthill's lab coerces flies to walk and allows for long-term 3D tracking. The researchers were able to analyze walking across various speeds in flies with and without impaired proprioception.

On the treadmill, flies walked in bursts, sprinting to the front of the treadmill chamber, and then rode the belt to the back. They spent roughly half their time walking. They would speed up when the belt did. Just as with humans and cockroaches, their body height rose when they walked faster. By using the treadmill in their experiments, the researchers obtained the fastest walking speed ever reported for fruit flies.

"They were able to surpass an instantaneous walking speed of 50 millimeters per second," the researchers noted.

The researchers also genetically silenced neurons underlying proprioception and ran the insects on the linear treadmill. Without this sensory feedback, flies took fewer but larger steps. Surprisingly, the coordination of their legs did not seem to be affected—perhaps because other proprioceptive neurons are more important to coordinate walking, or the nervous system may have compensated for the lack of feedback.

The scientists found that the split-belt treadmill had little effect on the coordination between legs. However, flies substantially changed the step distances of their middle legs when the two belts moved at different speeds. The researchers suggest that flies modify their steps to continue walking straight in the presence of rotational perturbations.

"The middle legs are ideally positioned to stably pivot the body of the fly about its center of mass, like rowing a boat from its center," the researchers explained.

The scientists noted that, "These insights illustrate how treadmills fill an important gap between free-walking and tethered preparations for investigating neural and behavioral mechanisms for fly locomotion."

The researchers have provided the software and hardware designs of these miniature treadmill systems as a free, open source for fellow scientists.

**More information:** Brandon G. Pratt et al, Miniature linear and split-

belt treadmills reveal mechanisms of adaptive motor control in walking Drosophila, *Current Biology* (2024). DOI: 10.1016/j.cub.2024.08.006

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