THE RACE FOR A NIMBLE OLD AGE

HIP PAIN? WITH CARA LEWIS'S ROBOTIC EXOSKELETON YOU MIGHT BE ABLE TO WALK IT OFF.

By Patrick L. Kennedy

You were taught to read and write. You were taught to do arithmetic. But chances are, you taught yourself to walk. And quite possibly you got it all wrong. Sure, you get from point A to point B. But you might also be damaging your hip. As a result, you could be on track to needing a hip replacement someday, according to Cara Lewis, an expert on gait and the musculoskeletal causes of hip pain. Fortunately, she's built a robotic device that can be used to teach both the healthy and the injured how to correct a hip-battering walk.

"My goal is to intervene early on, so that osteoarthritis doesn't progress—or doesn't even develop," says the assistant professor of physical therapy.

"There are a lot of questions in physical therapy that we don't know the answers to, like why one treatment works and another doesn't. I kept running into that as a clinician." So she got a PhD in Movement Science.

Lewis's biggest questions as a therapist were, "Why do people have hip pain, and how can I fix it?" The answers could help a sizeable population: Nearly 200,000 hips are replaced in the United States every year.

After completing her degree with a concentration in biomechanics, Lewis undertook postdoctoral work with kinesiology expert Dan Ferris at the University of Michigan, Ann Arbor. In a study of types of gait, Lewis and Ferris determined that walkers who push off harder from the foot take the stress off their hip joints.

< Every year, nearly 200,000 hips are replaced in the U.S. Changing the way we walk in our 20s could spare us that late-life pain, says Cara Lewis.

"You can experiment with this on the street," Lewis says. "If you push more with your feet, your legs kind of launch *themselves* forward."

Conversely, walkers who unwittingly rely on hip torque to swing their legs forward are using energy much less economically, Lewis says. They're also, by repeatedly straining the hip muscles, putting themselves at risk of injuring the tissue in their joints.

Hip pain can't be written off as a burden of old age, a sign of wear and tear. That wouldn't explain the increasing number of young people, especially runners and other athletes, who are now being diagnosed with acetabular labral tears. A source of hip pain that has been recognized only recently, labral tears heighten the risk of developing arthritis in the hip earlier than expected, says Lewis.

The labrum is a ring of fibrocartilage attached to the rim of the acetabulum, the hip socket in which the femur sits. "The labrum is some of the tissue that helps add stability, similar to that in the shoulder," says Lewis.

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The repetitive stress from an improper gait, Lewis believes, will cause hip pain, "which then progresses to a labral tear; you then start losing stability in the joint, which then leads to the arthritis—which [may result in the need for] a hip replacement. The replacement might be happening when you're 60, but it's because of something you did when you were 30.

"That's the population [20- and 30-somethings] to target. If you change the way they're walking now, you can change their pain after they already have a tear—*or* maybe change it *before* they get the tear." The way lies in "identifying the people who are at risk for the tear, and changing their mechanics."

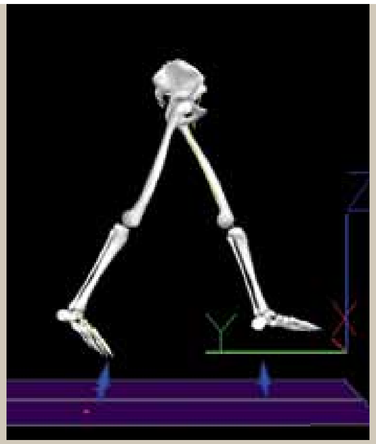
But how do you change the mechanics of a person's gait?

For Lewis, the answer came in Michigan, while she worked with Ferris on robotic exoskeletons for the ankle joints. "Because of advancements in orthotic materials, in actuator technology," Lewis explains, "we were able to finally move the technology to doing work at the hip joint."

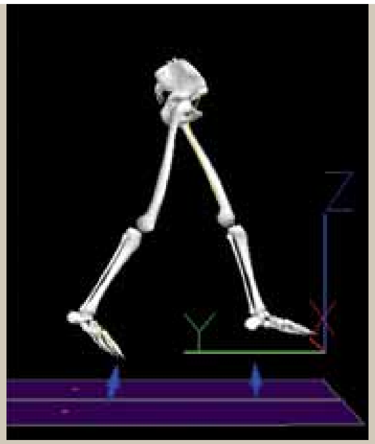
Lewis built a robotic orthosis, a pneumatically powered exoskeleton—more on the air tanks that power it later—consisting of a brace each for the waist and two legs. An orthosis is any device that supports or corrects limb or torso movement; splints and arch supports are orthoses.

Whereas Ferris focuses on studying how people walk, Lewis wants to change the way people walk. "She's in virgin territory," says Ferris. "She's using an orthosis for motor retraining rather than for assistive technology . . . That's what's novel."

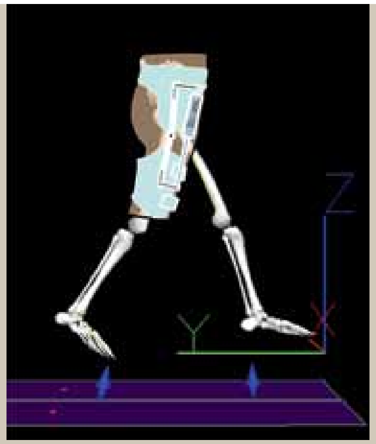
In a newly built lab at BU Sargent College, where Lewis has been teaching since fall 2009, healthy subjects wear the orthosis >>



A lazy walk.



A better walk.



The hip orthosis pulling the leg forward.

Capturing Walking Styles
The graphic representation of a patient's skeleton is generated by a special computer program in Assistant Professor Cara Lewis's lab in BU Sargent College's physical therapy department. "The representation allows us to measure the hip angle," says Lewis. In the first image, the hip and upper leg are dragging behind when compared to the second image (without the benefit of Lewis's sophisticated software or trained eye, you may need to look closely). "From the hip angle, we can see if the person is going into too much hip extension—the lazy walk." Lewis can then use a robotic orthosis powered by pressurized air tanks to "keep someone from getting into that bad position." Computer-generated images courtesy of Cara Lewis.

In the Lab
Eight cameras follow reflective markers on a subject and feed the data into a computer program. "The camera system and split belt treadmill make this lab unique," says Lewis.

>> while walking on a custom treadmill with two plates measuring force separately for the left and right foot. Electrodes on their legs record their muscle activity. And they are covered in reflective markers monitored by several motion-capture cameras.

"The computer system picks up the marker positions, and then can re-create a model of the skeleton," Lewis explains. "From that we can tell differences in angles, and figure out when we want to apply the robotic force, and how much."

That means when subjects exhibit what Lewis calls "the lazy walk," in which they're straining their hips by using them to swing one leg forward while the other leg lags far behind, Lewis presses a button. Air from a large pressurized air tank bursts into the orthotic actuators and corrects their gait.

"It'll start bringing your leg forward sooner," Lewis says, "so it keeps you out of that bad position" more effectively than verbal direction does.

Then, "Because I have such precise control over the timing and amount of assistance, I can wean people off of the bad position," Lewis says. "And then they can walk normally on the street."

Currently the lab is for research, not intervention. But Lewis envisions a time when this system is replicated in clinics all over. If you were recovering from a hip injury, you could make regular visits to a clinic to work out on the treadmill until you'd trained yourself to walk better. Furthermore, Lewis hopes, healthy people could use the orthosis to *prevent* a hip injury from ever happening.

No one can say whether this will work, because nobody's ever tried it, says Ferris. But if anyone can pull it off, it's Cara Lewis. "Most physical therapists—in fact, virtually all—do not have the level of technical understanding in terms of quantitative biomechanical analysis that she does," Ferris says. "She has a unique background that's going to really set her up for success regardless of what project she undertakes."

WEB Extra

From digital motion capture to real-time robotics control, learn more about Cara Lewis's lab at **www.bu.edu/sargent/human-adaptation-lab**.

Student Experience

Mary Khetani's research findings as a student could help occupational therapists improve the care they offer to families of children with disabilities.

How to Tame **Tantrums**

A DOCTORAL STUDENT'S RESEARCH BREAKTHROUGH COULD HELP THERAPISTS BETTER MEASURE THEIR IMPACT.

By Annie Laurie Sánchez

The playdate might not happen after all. The car fills with shrieks as the unwilling toddler acrobatically arches away from the car seat. For a parent whose child has been diagnosed with a disability—any parent for that matter—it can be hard to work out what to do next.

Enter the occupational therapist. They can work with a parent to help manage the situation by suggesting a cornucopia of strategies—things to say and do that help a child resolve or avoid a tantrum, among other things. But it's hard for therapists to know for sure what's working when, and why. Without any solid benchmarks for expected behavior in specific situations, professionals can't measure the impact of their strategies against anything. Before she joined BU Sargent College for doctoral studies in the Rehabilitation Sciences program, Mary Khetani ('10) was working as an occupational therapist and struggling to gauge her impact on clients; her attempt to solve the problem could change practice—and improve parental strategies—nationwide.

Khetani, now a newly minted doctor of science, began her work at Sargent with a close-up look at children who are supported by Part C early intervention: state-delivered services for families with kids aged 0 to 3 who've been diagnosed with, or are at risk for, disabilities or developmental delays. Her dissertation research involved reviewing information that researchers had gathered in a 10-year, 2,000-family national survey; she also conducted her own in-depth interviews with a small number of Boston-area families.

The process Khetani chose for those interviews surprised her with a breakthrough. When she started meeting families, they weren't sure how to interpret the standard, broad questions researchers typically ask. "You're not talking in the framework they're used to," says Professor Wendy Coster, chair of the Department of Occupational Therapy and Khetani's advisor. "Researchers think about models and theories, but that's not how parents think about their kids."

So Khetani, who became interested in occupational therapy as an undergraduate working at a summer camp for kids with disabilities, developed new language that parents could relate to. She stopped asking theory-based questions about family satisfaction—"Describe for me how your child functions on a typical day"—and started asking upbeat, activity-specific questions, such as, "Tell me how you can tell when things are going great while on a playdate with your child—what are you doing and what is your child doing?" She got results.

Khetani's revised approach helped her spot specific patterns of children's—and parents'—behavior during certain activities or under particular conditions. Her findings could provide a benchmark for therapists to determine which strategies are (or aren't) likely to work and when, such as when a parent's touch and tone, interactive toys, or sing-along music will result in a car trip ringing with giggles—or wails. Successful strategies mean more children developing toward their potential, more families leading fuller lives, and more successful playdates all around.

Her doctorate awarded, Khetani plans to continue her research. Armed with family friendly questions and newly discovered patterns of behavior, she hopes to develop easy-to-use benchmarks so that therapists across the country can measure the impact of their strategies—and help more parents tame tantrums.