SPECIAL EDITION

InsideSargent

Boston University College of Health & Rehabilitation Sciences: Sargent College

ACHIEVEMENTS IN **PHYSICAL THERAPY**

BOSTON UNIVERSITY

PROGRAM DIRECTOR'S MESSAGE

Dear Colleagues,

I am pleased to introduce this special issue of *Inside Sargent*, which highlights the educational, clinical, and scholarly activities in the physical therapy programs at Sargent College. Our highly accomplished faculty provide exceptional experiences for our students with breakthroughs in clinically applied research in state-of-the-art facilities. Our students are winning awards and presenting at national conferences under the guidance of faculty. We are modeling excellence in clinical education at the Boston University Physical Therapy Center where faculty and clinical staff embrace the interconnection of research and clinical practice.

Students are thriving with a dedicated interprofessional curriculum that includes students from physical therapy, occupational therapy, speech-language pathology, athletic training, and nutrition. Our highly successful post-professional education in the Neurologic Physical Therapy Residency and the Fellowship in Orthopaedic Manual Physical Therapy are producing leaders in the field. The mentorship experience between faculty and students is a key part of our work cultivating the next generation of clinical scholars.

As you will see in this issue, our faculty and students are engaged in a wide range of interdisciplinary teaching and scholarship activities. You'll read about innovative research to enhance the delivery of exercise interventions for patients with Parkinson's disease, modify gait patterns for individuals with knee osteoarthritis, and facilitate healthy walking in stroke survivors.

I hope you enjoy reading more about the inspiring activities in the physical therapy programs at Sargent College. I welcome your comments and feedback at pt@bu.edu.

Warm regards,

Diane M. Heislein
Director, Programs in Physical Therapy
Clinical Associate Professor

"THE MENTORSHIP EXPERIENCE BETWEEN FACULTY AND STUDENTS IS A KEY PART OF OUR WORK CULTIVATING THE NEXT GENERATION OF CLINICAL SCHOLARS."

SPECIAL EDITION InsideSargent

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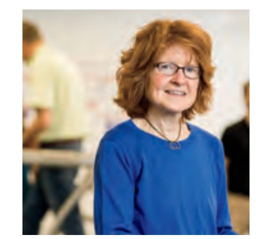
SPECIAL EDITION **InsideSargent**

Achievements in Physical Therapy



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MAKING A HABIT OF EXERCISE

A FIVE-YEAR STUDY AIMS TO REVOLUTIONIZE PARKINSON'S TREATMENT

Terry Ellis hopes that an app can help inspire people with Parkinson's to exercise consistently.

The data are clear: exercise helps people with Parkinson's disease. "Not only is exercise good for you but it slows the progression of disability," says Terry Ellis, an associate professor and director of Sargent's Center for Neurorehabilitation. "It may even slow progression of the disease."

But exercise is hard. It requires physical ability and daily motivation. "It's not like just taking a pill," says Ellis, chair of the physical therapy and athletic training department, who is joined by researchers at Washington University in St. Louis to study the use of an mHealth (mobile health) app to help—and even inspire—people with Parkinson's to exercise.

Based on the success of a one-year pilot study, Ellis and her colleagues recently received a five-year, $3.2 million NIH R01 grant to continue their work. They will follow the progress of 200 people with Parkinson's engaged in physical therapy and who begin exercise regimens. "We're trying to help people make exercise part of their everyday life," Ellis says. The model of care she's suggesting is like dental health: you see your dentist twice a year, but you also need to brush your teeth every day.

Here's how Ellis' treatment works: Participants begin with a series of face-to-face sessions with a physical therapist and receive a personalized set of exercises and a walking regimen to follow at home. The therapist films them doing the exercises, then creates videos with customized advice—all of which will be available in the app.

In between sessions, participants open the app on a tablet or phone to review their daily workout, receive personalized advice, and communicate with their physical therapists. They also respond to questionnaires, grading their progress and rating the ease or difficulty of the exercises. And, says Ellis, the therapists can adjust the workouts based on this information. Even in the months between in-person sessions, "You know somebody cares about what you're doing," she says.

The treatment works. In the one-year pilot study, participants walked, on average, 10 percent more than baseline, compared with a 12 percent decrease Ellis found in previous studies. But, she says, "We noticed that not everybody improved." Participants dealing with negative thoughts more frequently failed to reach their goals, she says.

That's where Ellis' colleague, Dan Fulford, comes in. Fulford, a psychologist and a Sargent assistant professor of occupational therapy, helped design cognitive behavioral elements for therapists to use in person and then for patients to use on the mHealth app. "The goal is to help people identify thoughts that might interfere with their walking or other exercises," Fulford says. That meant training physical therapists in some of the techniques of clinical psychology and designing elements of the app to positively modify behavior.

Those elements include the questionnaires, which create a sense of accountability, and a display showing the participant's goal, providing a constant reminder of how exercise will benefit them. These goals can range from "I want to be able to travel the world" to "I want to walk my daughter down the aisle." Users also receive feedback for tasks completed—the sort of visual validation people with Fitbits and other fitness trackers get. The aim is to help more participants stick to their regimen. "It's the cognitive behavioral piece that we think is kind of the secret sauce for our patients who struggle the most," Ellis says.

The study's impact could be far-reaching. "What I hope is that we can change standard practice so that patients with Parkinson's, when they're diagnosed, are routinely sent to a physical therapist—and they see them every six months, just like their neurologist," Ellis says. Beyond that, she thinks the results could even change the way chronic diseases, from arthritis to diabetes, are treated.

"Exercise is a powerful, effective treatment—and underutilized," she says. "We just need the data to drive policy change."*— Marc Chalufour*

DANA SMITH

COLLABORATIVE CARE

INTERPROFESSIONAL CURRICULUM MODELS REAL-WORLD TEAMWORK

Students from across Sargent collaborate in the innovative interprofessional education program.

It's a fall day, and 12 students from three Sargent College programs are bustling about a kitchen, helping people with a language disorder enjoy one of life's simpler joys: cooking.

The students—from the speech-language pathology, nutrition, and occupational therapy programs—discussed balanced diets, pored over recipes, and introduced adaptive cooking equipment tailored to the needs of clients with aphasia. This is one of several cocurricular interprofessional education (IPE) opportunities that complement Sargent's curriculum, enabling students from five disciplines—occupational therapy, physical therapy, speech-language pathology, nutrition, and athletic training—to learn from and about each other.

"In healthcare we are largely working in teams, and health issues are quite complex," says Craig Slater, a clinical assistant professor and director for interprofessional education and practice. "There's not one profession that usually can meet all of a patient or client's needs," Slater says. "We can introduce students to each other's disciplines and familiarize them with their colleagues' scope of practice."

Interprofessional education is relatively new, Slater says, having first emerged 20 years ago and achieved prominence in the last 10. Accrediting bodies are increasingly interested in students with interprofessional education experience; many require it.

Sargent's program, which began in 2017, involves online and face-to-face module learning, as well as guest speakers, case studies, simulations, and cocurricular activities.

The end result of the fall 2018 cooking session? Guacamole, quesadillas, chicken salad, and a clinical intervention that harnessed the best of each student's chosen profession. *— Geoffrey Line*

DAVE GREEN

GIVING BACK

Sargent doctor of physical therapy students participated in a day of service as part of their orientation. Groups volunteered at agencies around the city, including The Greater Boston Food Bank where students helped sort and pack food for hungry families across eastern Massachusetts.

Better Treatment Through Big Data

DATA ANALYTICS ALLOW PHYSICAL THERAPISTS TO CHOOSE TREATMENT APPROACHES

BY MICHAEL S. GOLDBERG

Clinicians, like James Camarinos (foreground), at the BU Physical Therapy Center gather data from 2,200 new patients, over 25,000 sessions, annually.

DAVE GREEN

If you have a sore shoulder, physical therapy is likely to make you feel better. But traditionally, it has been difficult for physical therapists to quantify exactly *how much* better a patient gets.

Now imagine you enter a clinic and, after describing your symptoms and having an exam, the physical therapist shows you a graph charting the progress of people with the same condition. The curve's trajectory details how you will improve and how many sessions it will take based on data from hundreds or thousands of patients who share your profile.

Patients in the BU Physical Therapy Center at the Ryan Center for Sports Medicine and Rehabilitation have started receiving such personalized charts. It's part of a quest for sharper, data-fueled insights into patient outcomes. Since September 2016, the clinic has been working with the Rehab Outcomes Management System (ROMS), a database and analysis software program developed by clinicians at Intermountain Healthcare in Utah. BU was one of the first institutions in the country to adopt the commercial version of ROMS. The system does for physical therapy what analytics have done for sports management (think of the movie and book *Moneyball*): using statistical evidence to drive decisions. Now, the BU facility, a Sargent clinical education center that operates independently and is open to the public, is using data to inform decisions on clinical approaches to common ailments, pursue new lines of research, and update the best practices taught to Sargent students.

"It helps us accurately track patient progress and help get people better faster," says James Camarinos, director of the center, which averages 2,200 new patients every year and around 25,000 physical therapy sessions annually.

With ROMS, BU's clinicians collect information from patients about how they feel at every visit using standardized questions based on a patient's condition: a patient with neck pain would be asked about, for example, the intensity of their pain and whether they experience discomfort bathing and dressing. The program turns their answers into data that clinicians can analyze to study the efficacy of treatment approaches for common ailments and make more precise predictions about outcomes, which can help set the right expectations for a patient experiencing pain.

"If you come to our clinic for rotator cuff tendonitis, there's a likelihood of success of 70 percent on the outcomes we use, and these are a good proxy of everyday function," says Camarinos.

PT SUCCESS RATES

Neck pain from whiplash	All patients 75%	Patients with at least 8 visits 83%
Rotator cuff tendonitis	All patients 70%	Patients with at least 7 visits 77%
Low back pain	All patients 72%	Patients with at least 6 visits 78%

But delving into the data further shows that for those who average seven visits, the chance of success rises to 77 percent. It's a way to convey to patients the benefits of sticking with physical therapy after the first few visits to the clinic. "We're making that statement not just based on experience alone, which is of course highly valuable, but also based on data science."

That opportunity to use data analysis to ask new questions about the effectiveness of physical therapy treatments is especially important at a time when healthcare providers are looking to find cost-effective ways to deliver quality results, says Lee Marinko, a clinical associate professor of physical therapy and athletic training.

Prior to the adoption of ROMS, information about how patients felt was incomplete and imprecise, she says. "The problem with not collecting standardized outcomes is that everybody gets better when they go to physical therapy, because they just feel better. But what is it about what we do that really *makes* them better?"

Traditionally, physical therapists used patient satisfaction scores, as well as measurements of physical impairment, like the range of motion in a knee or shoulder. Through such measurements, a therapist could discern improvements. But the quality of such readings was variable: different physical therapists asked different questions, for instance, and they did not ask them at every visit.

Today, says Marinko, BU's clinicians can analyze data they collect to identify factors that could improve care and compare the experiences of their patients to others with the same conditions nationwide. One project that Marinko and her colleagues are pursuing, for example, is studying how long it takes for a patient to see a physical therapist after calling the clinic, and correlating that answer with patient results. How much difference can it make to get a patient into sessions right away? The new data will help answer that question.

Another question is about patient copayments. "Insurance copayments have changed dramatically, with more of the burden coming to the patient," says Marinko, who is also a clinician at the center. "If you have to pay more, do you come for fewer visits and therefore not get as good of an improvement?"

With six Ryan Center physical therapists also holding teaching positions at Sargent and students often completing internships at the center, advances pioneered in the clinic quickly find their way into the classroom—and vice versa. Marinko points to a ROMS analysis that identified risks in certain patients who should be referred to a doctor to reduce the chance they will suffer a prolonged disability. The insights led to better, more personalized care and, in turn, have informed the best practices Marinko teaches her students.

"The data allow us to ask questions to improve care and then change the way we teach our students," Camarinos says. "It's an established thing in medicine, that we know that it can take up to 17 years to get a new discovery into real-life practice. We hope to shrink that timeline." ■

This article was originally published in the 2019–2020 issue of *Inside Sargent*.

Weighted Walking

HOW CARRYING A SIMPLE HAND WEIGHT CAN EXERCISE WEAK HIP MUSCLES

BY LARA EHRLICH

Kerri Graber ('17,'19), a former track athlete, wanted to understand how the body works. She found a home in Cara Lewis' Human Adaptation Lab.

MICHAEL D. SPENCER

Imagine a model walking down the catwalk, her skirt snapping with the dramatic lift and fall of her hips. While that walking pattern is an affectation of high fashion, a less exaggerated version is just as common off the runway.

When walking naturally, your hip abductor muscles fire, tipping your pelvis up and down. If the hip of your weight-bearing leg is weak, however, your opposite hip drops further to compensate, tilting your pelvis down at a steeper angle. That walking pattern, called pelvic drop, can cause inflammation, tendonitis, and other painful conditions in your hips and knees.

Everyone from athletes to octogenarians is susceptible to pelvic drop. Kerri Graber ('17,'19), a doctor of physical therapy student, has helped evaluate an exercise to prevent it. Along with her mentor, Cara Lewis, she found that a simple hand weight can have a big impact on hip muscles—and can be used both in the clinic and at home.

Graber was drawn to physical therapy when she was a member of the BU track team and needed physical therapy for minor injuries. "I wanted to learn more about how the body works, how it ages, and how it heals," she says, "and to find ways to help people become more mobile and recover from injury faster."

During her second year of Sargent's six-year accelerated Doctor of Physical Therapy (DPT) program, Graber enrolled in a biomechanics course taught by Kenneth G. Holt, an associate professor emeritus. "It was super cool to quantify movements of the body and understand how movement at the hip, for example, can affect what's happening at the foot," she says. "That understanding of movement up and down the chain of the body is fascinating to me."

For further study in biomechanics, Graber's academic advisor connected her with Lewis, an associate professor of physical therapy, whose Human Adaptation Lab focuses on motor adaptation—how our bodies learn and modify movements—specific to reducing hip pain. Lewis is a pioneering advocate for rehabilitation as prevention, with work funded by the National Institutes of Health. Her lab was a natural fit for Graber, who's been there ever since.

In her fifth year of the DPT program, Graber worked with Lewis to develop a practicum project to alleviate pelvic drop.

"Kerri had to do a lot to figure out that research project," Lewis says. "How are we going to test it? What are the specifics of the protocol?"

"I couldn't have asked for a better mentor," Graber says. "Cara not only taught me how challenging it can be to put together a research project, but also how rewarding it can be; she guided me through the steps of designing a research project, from creating a clinical question all the way through data processing and drafting an abstract for submission to a conference."

First, the researchers acquired baseline data, measuring their subjects' muscle activation with electrodes placed on their skin while walking on a treadmill. Then, they measured the subjects' muscle activation when they held a kettlebell, weighing 15 to 20 percent of their body weight, opposite the side with pelvic drop. Graber and Lewis found that those muscles activated more to counterbalance the weight and stabilize the pelvis.

Graber found the perfect mentor in Cara Lewis (left), a pioneering advocate for rehabilitation as prevention.

> "I wanted to learn more about how the body works, how it ages, and how it heals, and to find ways to help people become more mobile and recover from injury faster."
> —Kerri Graber ('17,'19)

"Across the board, we found significant increases in muscle activation when subjects were walking with the weight, compared to their baseline walking," Graber says. As the researchers expected, the exercise did not increase muscle activation on both sides of the pelvis; "it just targeted the side we wanted."

Graber presented the research at the 2019 Combined Sections Meeting of the American Physical Therapy Association, where her peers were excited by the exercise's potential beyond the clinic. Graber's next step is to figure out how the intervention can be done in the home.

"A big question is how to help patients who are elderly and have hip weakness, but can't carry 15 to 20 percent of their body weight in their hand," Graber says. "We need to determine the minimum amount of weight needed to increase muscle activation enough to strengthen the hip."

She also intends to adapt the intervention so those with hip weakness can work on the exercises during their daily routines. One example: carrying grocery bags in the arm opposite the weak hip, Graber says. "Just functional ways to get those muscles activating more. You don't need to carry around a 15-pound kettlebell; you could do this exercise on your walk home from the grocery store." ■

This article was originally published in the 2019–2020 issue of *Inside Sargent*.

CONOR DOHERTY

MINDFUL WALKING

A TAI CHI–INSPIRED TECHNIQUE COULD HELP PEOPLE WITH KNEE OSTEOARTHRITIS WALK MORE—WITHOUT FURTHER DAMAGING THEIR JOINTS

BY ANDREW THURSTON

It's a bit of a chicken-or-the-egg conundrum. People with knee osteoarthritis don't walk enough, which can leave them stiff and put them at a higher risk for other health problems. But, when people with knee osteoarthritis do walk, they tend to be a biomechanical mess, overactivating their muscles, walking bowlegged, or putting more pressure—called joint loading—on the knee. This further damages their cartilage, aggravating the condition and increasing their discomfort. In response, they walk less.

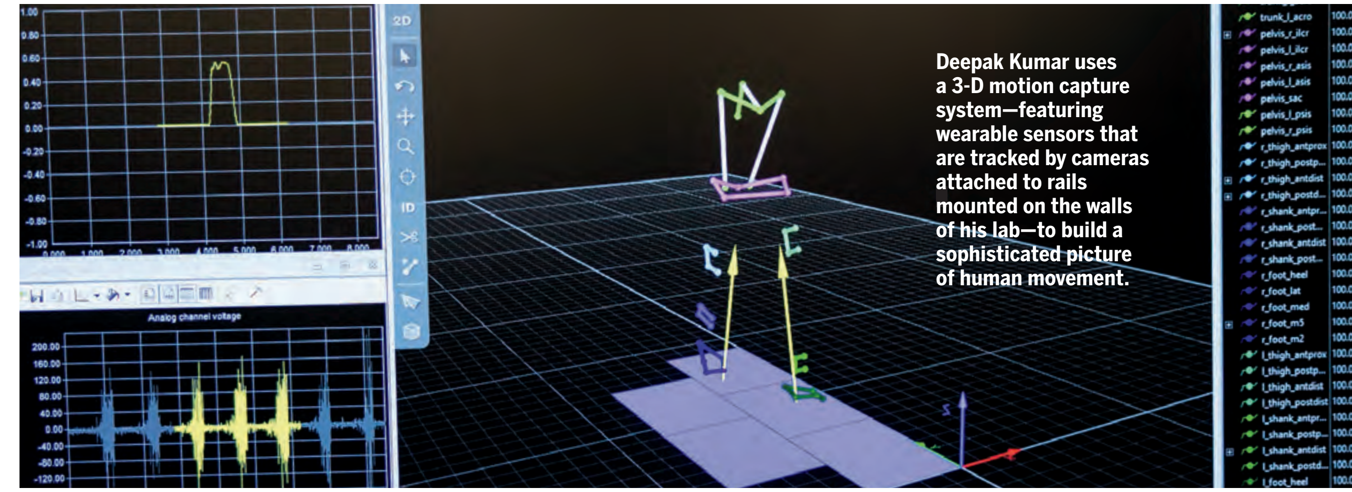
"We have these two problems," says Deepak Kumar, an assistant professor of physical therapy and athletic training. "The trick is, how do we solve them both?"

About 14 million people in the United States have symptomatic knee osteoarthritis, according to a 2016 study published in *Arthritis Care & Research*. The joint cartilage is gradually degrading, the meniscus—the shock-distributing cartilage—getting torn and worn down, and muscles steadily weakening. It adds up to difficulty walking and chronic pain. Physical therapy, weight management, painkillers, and steroid injections provide some relief, but for more than half of sufferers, those limping through the condition's advanced stages, a total knee replacement is probably the only remedy.

Kumar's goal is to limit or delay surgeries, but first he must fix that chicken-or-the-egg problem: helping people become more active and ensuring their newfound enthusiasm for fitness doesn't make their knee osteoarthritis worse.

He got a glimpse of a potential solution while he was a postdoctoral researcher at the University of California, San Francisco. There, Kumar worked with Professor Frederick Hecht on a project testing ways of encouraging people with prehypertension to be more active. As part of the clinical trial, one group of participants was trained in a technique called ChiRunning, which is inspired by tai chi and applies mindfulness practices to improve running form. The fundamental tenets, says Kumar, are "increased body awareness, engaged core, reduced stride length, midfoot strike, increased step rate, and relaxed upper body." His job was to conduct motion analysis on the participants at the beginning of the trial and three months later; he found their biomechanics—how the body and muscles work together to propel someone forward—had shifted.

"The ChiRunning group showed changes in their movement patterns that seemed to suggest their loading on the knee was lower," he says. They weren't putting as much pressure on the joint, particularly the inside of the knee, or putting their foot as far in front of their body; the researchers concluded that the biomechanical differences "may be associated with reduced lower extremity stress."



Deepak Kumar uses a 3-D motion capture system—featuring wearable sensors that are tracked by cameras attached to rails mounted on the walls of his lab—to build a sophisticated picture of human movement.

"I thought, 'OK, this should work for osteoarthritis,'" says Kumar. He started a small second study with healthy subjects to take a closer look at ChiWalking, which uses similar techniques as its running counterpart. He found it also reduced impact forces on the body, and the knee in particular.

Now, with a grant from the National Institute of Arthritis and Musculoskeletal and Skin Diseases, he's launched a feasibility project to see if ChiWalking can help people with knee osteoarthritis. For six months, one group will attend regular ChiWalking sessions, while a second will participate in classes on osteoarthritis and the importance of exercise. At key stages in the study, Kumar will bring the subjects into his Movement & Applied Imaging Lab at Sargent to measure their walking patterns and quantify the amount of force their knees are bearing. The lab has a 3-D motion capture system—subjects wear small sensors that are tracked by cameras attached to rails mounted on the walls—and a force platform built into the floor; participants also wear electromyography sensors that measure muscles' electrical activity. Kumar, who teaches Instrumentation for Analysis of Motion, a course focused on using technology in research, has eight undergraduates in his lab to help him and his research fellow process the data.

But he's aware that for the ChiWalking intervention to be a success—improving gait and helping people get and stay active—it'll need to work without the fancy equipment.

"Traditional approaches on changing how people walk require them to come to a lab like we have and then be shown their data and how to change it," says Kumar. "That's very time and cost intensive. You have to do it one person at a time."

For the second six months of the ChiWalking project, the emphasis will be on helping participants stay active—safely—without visiting the lab. Study participants will be given a fitness tracker and access to a mobile health app. The app, which Kumar is developing in collaboration with BU's Software & Application Innovation Lab, pulls in activity data from the tracker, asks questions about mood, sleep patterns, and pain levels, and sends motivational messages. Users can also set goals, while a physical therapist can monitor progress to help them stay engaged with the program.

> "If we target pain and problems with mood and sleep, as well as physical activity, we're more likely to be successful in getting people with osteoarthritis to be more active."—Deepak Kumar

"If we target pain and problems with mood and sleep, as well as physical activity, we're more likely to be successful in getting people with osteoarthritis to be more active; people who have these problems tend to be least active and are at greatest risk of developing other health problems," Kumar says.

That fits with his other ongoing research projects, which emphasize finding ways to better monitor patients as they go about their daily lives. In the lab, he says, subjects usually wear light clothing, are plastered in sensors, and watched constantly—and there are no bumpy sidewalks or uneven paths to navigate. "They always end up changing slightly how they're walking."

Kumar recently tested the ability of a small inertial sensor—an inexpensive, eraser-sized gadget that includes a gyroscope—to track movement and gait without the need for all the cameras and force plates. When put on the thigh, the sensor can track the knee as the foot hits the ground, monitoring any varus thrust, a quick, but damaging, outward movement of the knee. He presented the results at the 2018 American Society of Biomechanics annual meeting.

If Kumar's ChiWalking studies are successful, it could provide hope for the millions of people experiencing symptomatic knee osteoarthritis. The combination of consumer technology and a commercially available gait training technique will allow the intervention to be done in group settings at a low cost. "It's very scalable," Kumar says. ■

This article was originally published in the 2018–2019 issue of *Inside Sargent*.

Terry Ellis received a five-year, $3 million grant from the National Institutes of Health for an exercise program with an mHealth component.

JAKE BELCHER

Slowing Parkinson's

WHY EXERCISE IS ONE OF THE BEST MEDICINES | BY BARBARA MORAN

Each year, doctors diagnose about 60,000 Americans with Parkinson's disease, a progressive neurodegenerative disorder that can lead to tremors, limb and facial rigidity, and balance and walking problems. There are treatments, but no cure.

One of the best therapies turns out to be one with no cost and few side effects, says Terry Ellis, chair and associate professor of physical therapy and athletic training and the director of Sargent's Center for Neurorehabilitation. That treatment, says Ellis, is exercise.

Ellis, who directs the American Parkinson Disease Association National Rehabilitation Resource Center at Boston University, has been working with patients and studying the neurology of Parkinson's for 20 years. Widely recognized as a national leader on the subject, Ellis has received many teaching and research accolades, including the 2019 Excellence in Neurologic Research Award. Presented by the Academy of Neurologic Physical Therapy, the award acknowledges a member and physical therapist who has demonstrated continued excellence in research, science, theory, practice, or education.

Ellis has also pioneered work on using mobile health (mHealth) technology like iPads to help people with Parkinson's keep moving. With Gammon Earhart, a professor at Washington University in Saint Louis, she recently received a five-year, $3 million grant from the National Institutes of Health to enroll 200 people with Parkinson's in a one-year exercise program with an mHealth component to study how well it works and why.

We spoke with Ellis about how Parkinson's treatment has changed through the years, and her outlook for the future.

***Inside Sargent:* When you were first working as a clinician, 30 years ago, how did you treat people with Parkinson's? What was the standard practice?**

Ellis: Back then, we thought, "Oh, these people have a chronic progressive disease; they're just going to get worse." We didn't really expect them to improve, so we just taught them strategies to get by. Like, "If you can't stand up out of a chair by yourself, here's how someone might help you."

And what was the understanding of the effect of exercise on Parkinson's?

At that time, there were almost no studies looking at the benefits of physical therapy or exercise for people with Parkinson's. It wasn't until the 1990s that there were some animal studies done in rats and mice with Parkinson's. And scientists found a potential neuroprotective effect, meaning that maybe exercise does something to slow down the progression of the disease or to protect cells from dying.

> "We promote people coming directly to physical therapy at the point of diagnosis [so that we can] prescribe an exercise program that's tailored to their needs." —Terry Ellis

What do we know about exercise and Parkinson's now?

Studies conducted here at Sargent as well as by other research groups looking at the benefits of physical therapy and exercise for people with Parkinson's have shown improvements in things like walking and balance. Most of those early studies were short-term; you could make a difference over 8 to 12 weeks. What about longer? People with Parkinson's live a long life and want to live well.

In the last five years or so, more long-term studies have come out looking at what happens if you exercise consistently for a year or two. The results show that people with Parkinson's who exercise do better than people who don't.

Why? What's happening?

We know that exercise improves overall brain health. But in Parkinson's, there may be an increase in neurotrophic factors that protect sick cells from dying. We don't know for sure. We see improvements at the functional level. We see that people can walk better for a longer period of time. We see that balance can improve. We see that strength can improve. So now exercise is becoming part of the standard recommendations for treatment for people with Parkinson's.

Are there issues with exercise that are particular to people with Parkinson's?

Yes. First of all, they have mobility problems, so they can fall, they have a shuffling gait, they're slow. These can make it difficult to exercise. But I think, more important, there are issues related to depression and apathy, and they may have poor confidence in their ability to exercise successfully. These factors make it even more difficult to overcome that inertia. Also, the number of people in the United States with Parkinson's who are referred to physical therapy is around 14 percent. That's terrible. In my mind, it should happen for everybody right away.

Do other countries do it better?

Yes, because other countries with socialized medicine aren't dealing with third-party payers. If you have Parkinson's in the Netherlands, you can just go to a physical therapist and get treatment.

We promote people coming directly to physical therapy at the point of diagnosis. Then we can do a battery of tests to get a baseline assessment—what's your initial walking ability, your balance, your quality of life—so that we have solid data. And then we prescribe an exercise program that's tailored to their needs.

Are there certain types of exercise that seem especially beneficial for people with Parkinson's?

It seems that there may be a neuroprotective effect from aerobic exercise. There are also studies showing that progressive resistance exercises or strengthening exercises help people with Parkinson's who have bradykinesia, or slowness of movement, to turn on their muscles faster so that they can move more efficiently. Balance exercises are also very important because of the fall risk.

I was wondering whether they should avoid exercises requiring balance.

Well, at one time, that was the recommendation. But if you sit too much, you're going to be so deconditioned, that creates a whole other cadre of problems. And so we recommend people move, and move a lot.

How does mHealth fit into that?

When we see people every six months, they still have to exercise independently between visits. So what we've been doing is using a mobile health platform, an app. People have their device—either their iPad, tablet, or their smartphone—and we use an app that shows videos of their exercises. So they get home, open the app, and then they can see the exercises that we've prescribed for them and remember how to do them. After they finish the exercise each day, they answer certain questions, like, Was this hard or easy? How many did you do?

Then the therapist can check the data. And based on the responses, we can remotely adapt the exercise program so we can keep it interesting. One of the big things that patients report to us is that accountability makes a difference. They know that you're watching, and they know they're coming back in six months to be remeasured, and they want those numbers to improve. They want to take control of this disease.

Where do you hope treatment will be 20 years from now?

Well, maybe we'll have a cure. But I think what might happen is that there will be a "buffet" of treatments that slow the progression of the disease. And one of those will be exercise. And I hope that we have a system in place across the United States so that everybody gets this, not just people in the know. ■

This interview has been condensed and edited for clarity.

This article was originally published in the 2018–2019 issue of *Inside Sargent.*

MOVE OVER, IRON MAN

A SOFT, WEARABLE ROBOT COULD HELP PEOPLE WALK FARTHER AND FASTER AFTER A STROKE

BY ANDREW THURSTON

ROLEX/FRED MERZ

Powered by a chunky robotic suit, Iron Man can leap from buildings and soar into space. The superhero's gold and titanium getup might look great when taking down villains, but it'd be overkill for spending a morning with the grandkids. For people who are recovering from a stroke and want to get back to enjoying their favorite activities, there's something better: a soft, lightweight, bionic walking aid that straps to the leg and can be worn anywhere.

Sargent physical therapy professors Lou Awad and Terry Ellis are part of the team behind the medical exosuit, a wearable robot that can help people who have had a stroke walk faster, farther, and more safely. Instead of Iron Man's titanium, it has breathable wraps made from proprietary materials, thin cables, and a series of small motors that help it mimic human muscles and tendons.

The technology has already been licensed and a suit could be commercially available for use in clinics within the next few years. That would be life changing for thousands. Every year, 795,000 Americans have a stroke, which stops blood flow to parts of the brain and can leave survivors with chronic weakness or paralysis, turning walking into a frustrating—even dangerous—chore. For 15 to 35 percent of survivors, learning to walk independently can take more than six months. Many of those who do learn to walk again will not regain their former speed or stability; according to *Stroke Connection* magazine, about 40 percent of all survivors have a serious fall within a year of their stroke.

EQUALING NATURE

For a robot, the exosuit is understated, more high-tech sports brace than sci-fi cyborg; it weighs only about 10 pounds. A matchbox-sized sensor attaches to the outside collar of the shoe close to the ankle, while two black wraps cover most of the lower leg and the waist. Cables, similar to those used to control bicycle brakes, run from inside the wearer's shoe to their calf and from the shoe's tongue to their shin. Motors—worn around the waist and regulated by a computer unit loaded with algorithms—apply forces through the cables to help the wearer walk.

"People who have had a stroke have trouble with dorsiflexion, or foot clearance," says Ellis, chair of physical therapy and athletic training; they have a reduced ability to bend their ankle and lift their foot. When they try to plant their heel on the ground to walk, they instead "drag their toes and their foot gets caught." The exosuit counteracts that issue by retracting the cable attached to the shoe's tongue, applying a small amount of force to bring the toes up. When the wearer needs to take a step forward, the rear cable contracts to ensure their foot pushes off the ground, a movement called plantar flexion.

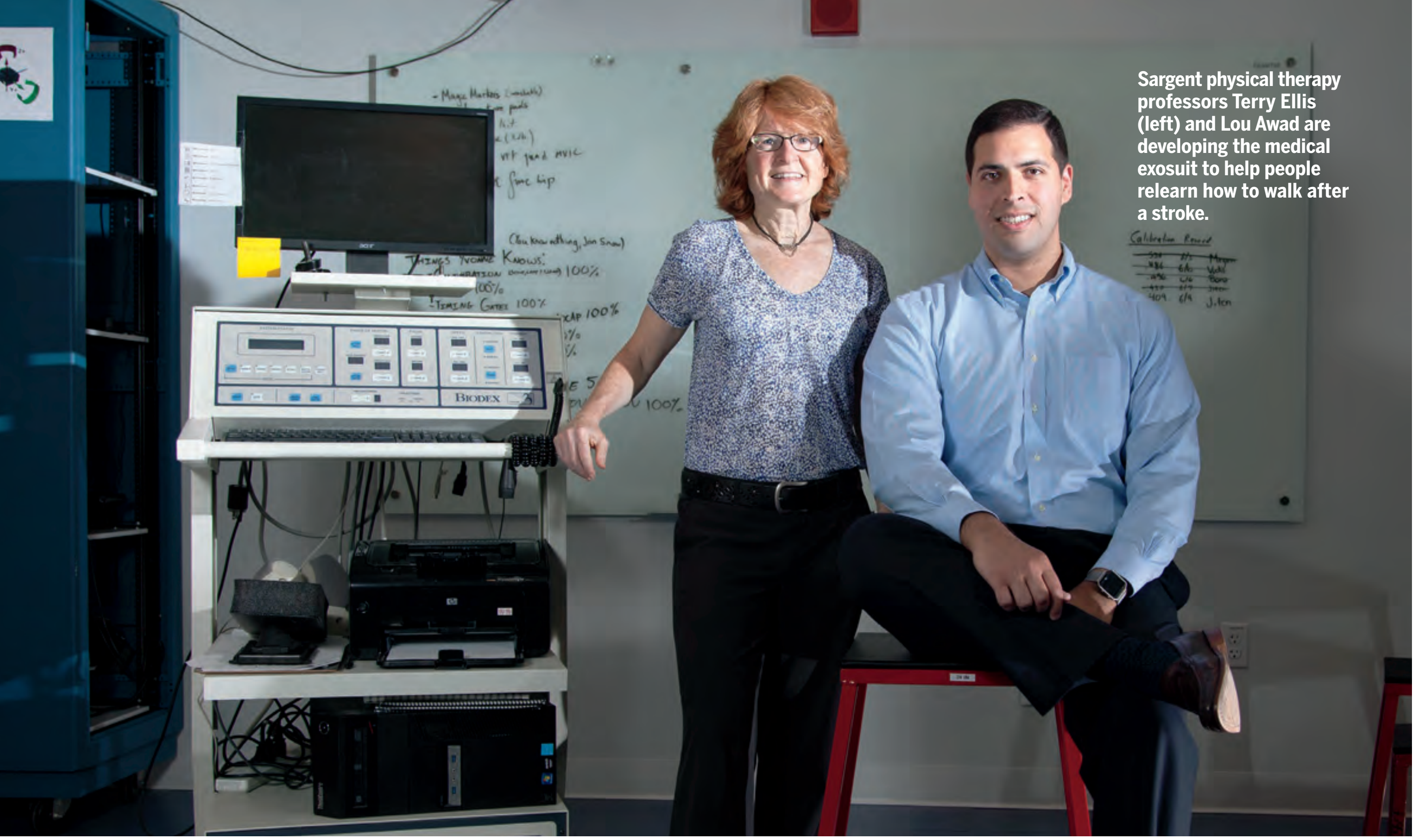
The exosuit traces its roots to a soft robot designed for the military by a team at the Harvard Biodesign Lab at the Wyss Institute for Biologically Inspired Engineering at Harvard University. That suit, developed in collaboration with Sargent's Kenneth Holt, an associate professor emeritus of physical therapy & athletic training, is intended to help soldiers and emergency personnel carry heavy loads with minimum effort. With a similar cable, wrap, and motor combination, it works in harmony with the body to help reduce the strain associated with lugging hefty packs. By applying assistive forces to the ankle and hip, the suit—which is still in development—reduces the amount of energy needed to carry a load equivalent to 30 percent of a wearer's body weight by around 7 percent, according to a study published in the May 2016 *Journal of NeuroEngineering and Rehabilitation.*

> "The goal with the military suit is to beat nature, break that barrier that nature provided. With the medical exosuit, the goal is to bring people back to where they were."—Lou Awad

To adapt the suit to a medical purpose, Wyss and Holt—a biomechanist who worked with engineers to inform the suit's therapeutic applications—invited Ellis and Awad to join their team of engineers, computer scientists, and business developers. They needed "researchers who are embedded in the clinical world and work with patients," says Ellis, director of the BU Center for Neurorehabilitation. The first major challenge was a practical one. The military suit was designed for "fit individuals who can handle the high amount of force" the exosuit applies to the body, says Awad.

For the suit to work, the wearer needs to be able to bear the typical forces our muscles, tendons, and bones absorb every day, as well as those the exosuit adds. That's less of an issue for an athletic solider than it is for a person who has suffered a stroke.

When developing the medical version, the team began by exploring less rigid textiles than those used for the military suit. "The first prototypes used seat belt webbing," says Awad, director of the BU Neuromotor Recovery Laboratory; in contrast, the medical suit is made of "composite materials that create a secure, breathable, and form-fitting interface with the wearer's leg." They



Sargent physical therapy professors Terry Ellis (left) and Lou Awad are developing the medical exosuit to help people relearn how to walk after a stroke.

made other changes, too. Although the original is worn on both legs versus the medical suit's one leg, it only assists with the pushing off—the military doesn't have to worry about soldiers dragging their toes. "The goal with the military suit is to beat nature, break that barrier that nature provided," says Awad. "With the medical exosuit, the goal is to bring people back to where they were."

Both versions of the suit have sensors that tell the computer control unit—Awad calls it the brain—where a person is in their stride, so it can deliver the right amount of force for each individual. The brain is adaptive, says Awad, "so if a person suddenly starts walking faster or changes their cadence, it recognizes that and responds accordingly." It should eventually allow wearers to navigate uneven terrain, although testing has so far been limited to the lab.

Awad says the suit's on-the-fly thinking is one of the features that sets it apart from others in development—and one of the Sargent team's major contributions. Like the less rigid fabrics, the algorithms plugged into the medical exosuit's control unit also help ensure it doesn't put too much pressure on the wearer's body.

"It's a product of a deep understanding of how people move and how movement goes awry after something like a stroke," he says. "That came from our discussions with the biomechanics team, the engineers, teaching them how people with a stroke move; they didn't have that experience."

"OMG! OMG! OMG!"

The medical exosuit is light years ahead of the current alternative for rehabilitation after a stroke: the ankle foot orthosis, an ungainly contraption of molded plastic that's been in use since the early 1980s. The stiff boot runs down the calf and under the heel, holding the leg and foot at a 90-degree angle. By keeping the ankle locked, the orthosis prevents the wearer from stubbing their toes and tripping, "but because you have a rigid 90-degree angle, you can't push off, so you sort of lift the leg and lose some of the key features of a normal gait," says Ellis. The boot allows people to gain a degree of independence, but it doesn't get them back to the activities they love. And, Awad adds, it may bring its own complications. "If you had a stroke at a young age," he says, "the muscles that may not have been directly impacted by the stroke are going to suffer."

In testing, some participants wearing the medical exosuit have been able to nearly regain their pre-stroke walking speeds. In one exosuit testing session, the user began outpacing the physical therapist monitoring his progress. In another, Awad watched as a participant began shouting, "OMG! OMG! OMG!" in happiness. "She told me, 'I was thinking about my grocery list; I'm never able to think about anything except walking, the next step in front of me, otherwise I'm going to fall.'"

In a series of presentations and journal articles, the researchers have quantified the suit's impact. They found participants pushed off from the ground more effectively and used less energy, and that they walked faster over longer distances. The research, which began with military funding through the DARPA Warrior Web Project and has also been supported by the National Science Foundation, Wyss Institute, Harvard Paulson School, and American Heart Association, was published in the July 26, 2017, issue of *Science Translational Medicine*. The principal investigator is Conor Walsh, an associate professor of engineering and applied sciences at Harvard and a core faculty member at the Wyss Institute.

Ellis notes that the suit doesn't replace physical therapists in stroke rehabilitation. Instead, it could be used to help people relearn walking in the immediate aftermath of a stroke and allow them to practice walking at home after being discharged.

DANA SMITH

ROLEX/FRED MERZ

A SENSOR TELLS THE COMPUTER CONTROL UNIT WHERE A PERSON IS IN THEIR STRIDE SO IT CAN DELIVER THE RIGHT AMOUNT OF FORCE FOR EACH INDIVIDUAL.

"In this country, once you've had a stroke, after about three months, you're done with all the rehab," she says. "It's a real drawback because there are a lot of studies that show that rehab in the chronic phases is very effective and can enhance function. A therapist could prescribe the exosuit with parameters helpful for each individual."

PERFECTING THE SCIENCE

The team is pursuing funding to investigate how best to use the exosuit beyond the lab and recently won a National Institutes of Health grant, awarded through the National Institute of Child Health and Human Development, to continue developing the technology. They plan to explore other applications, like customizing the suit to help people with Parkinson's disease, multiple sclerosis, or cerebral palsy. For now, though, the primary goal is getting the suit ready for people who have had a stroke. The medical exosuit currently only augments the ankle, but a new project with Harvard will focus on a system that integrates support for the knee and hip.

In a separate project, funded by a BU Clinical & Translational Science Institute pilot grant, Awad is studying ways to improve how wearable devices like exosuits sense and assist impaired movement. He says the current sensors are good at tracking data like joint angle and joint speed—how fast the leg is moving—but not as successful at determining the activity associated with that movement: is the user walking or marching in place, are they turning or walking in a straight line? With Roberto Tron, an assistant professor at BU College of Engineering, he's exploring systems that could compute both.

According to ReWalk Robotics, the company that has licensed the technology, the current version of the medical exosuit could—pending FDA approval—be ready to ship as soon as 2018. It won't help anyone swoop into the stratosphere like Iron Man, but it could give plenty of grandparents the chance to play superheroes again. ■

A LOADED RESEARCH QUESTION

DO MALE AND FEMALE SOLDIERS CARRY THEIR EQUIPMENT DIFFERENTLY?

BY SARA RIMER

CHRIS MCINTOSH

Helmet, uniform, boots, armor, weapon, ammo, food, canteens, compass, first aid kit—everything a soldier wears and carries (their "load") can add up to more than 68 pounds. In a combat mission, that weight can skyrocket to as much as 120 pounds. Carrying a heavy load while walking, marching, running, or even fighting is essential for every soldier, regardless of gender.

"A soldier can't say, 'I can't carry this much water because it weighs too much,'" says Kari Loverro ('19), a doctoral candidate who is studying the biomechanics of how soldiers carry heavy loads. "You have to carry what you need for the mission." All that weight is associated with high rates of stress fractures and other musculoskeletal injuries to soldiers' hips, legs, feet, and ankles. For female soldiers, the risk of stress fractures to their lower extremities is 2 to 10 times greater than for their male counterparts. Loverro wants to know why.

Her study comes at an important time for the military. While increasing numbers of women are serving in combat roles—the Department of Defense (DOD) lifted its ban on women in combat in 2013—there has been relatively little research on how female soldiers carry heavy loads. In general, women are shorter, and weigh less, than men. So while they are required to carry the same load as men, their relative load is greater.

To figure out if men and women carry their load differently, Loverro is modeling pressure between the bones of the hip during walking. In Sargent's Human Adaptation Lab, she outfits a group of volunteers with weighted vests that represent the loads of up to 60 pounds that soldiers may have to carry on their torsos during foot marches and combat missions. Those volunteers march on a treadmill at varying rates of speed while Loverro uses high-tech sensors, reflective markers, motion cameras, and computers to track their every movement.

In her ongoing study, Loverro is investigating whether soldiers adapt to a heavier load on their torsos by leaning forward, or slowing down, or taking shorter steps, and whether the load makes them more likely to fall. She hopes to learn how men and women change the way they walk when carrying heavy loads at different speeds, and how these adaptations may cause stress and even harm to their bones. Loverro, who is pursuing a doctorate in rehabilitation sciences, hopes her study will lead to interventions that can prevent injuries to soldiers, men as well as women.

"Our soldiers put themselves at risk in ways we cannot control," says Loverro's mentor Cara Lewis, an associate professor of physical therapy who directs the Human Adaptation Lab and teaches in the PhD program in Rehabilitation Sciences. "We should at least control the ways we can reduce the risk of musculoskeletal injury in training and when carrying a load."

Loverro has a personal investment in her research. Her father is a retired Air Force colonel and was deputy assistant secretary of space policy under President Barack Obama. Her mother, a retired Air Force lieutenant colonel, was a professor of aerospace studies in BU's Reserve Officer Training Corps program in the 1980s.

A SOLDIER'S RECOMMENDED LOAD

68.9 lbs.

INCLUDES:

7.8 lbs. uniform	**16 lbs.** armor plates
4.2 lbs. combat helmet	**0.5 lbs.** compass
6.4 lbs. M4 assault rifle	**1 lb.** first aid kit
4.6 lbs. 1-qt canteens of water (2 per soldier)	**2 lbs.** M67 fragmentary grenades (2 per soldier)

From the US Army Field Manual, *1990*

> "Our soldiers put themselves at risk in ways we cannot control. We should at least control the ways we can reduce the risk of musculoskeletal injury."
> —Cara Lewis

"I am honored to come from a military family," says Loverro, who spent four years as a postgraduate research fellow on the biomechanics team at the US Army Natick Soldier Research, Development and Engineering Center (NSRDEC) in Natick, Mass. "Even though I do not wear the uniform, I feel that this is my way of giving back to the men and women who put their lives on the line to protect us. I want to make sure that every soldier has the best possible chance of staying safe in the field while performing their mission." ■

Kari Loverro was awarded a DOD Science, Mathematics and Research for Transformation (SMART) Scholarship for Service, which paid for her final two years at Sargent and ensures her return as a civilian researcher to NSRDEC. Her dissertation research is funded by a $5,000 grant from the Dudley Allen Sargent Research Fund.

This article was originally published in the 2017–2018 issue of *Inside Sargent*.

Faculty in Print

OUR FACULTY'S RESEARCH REACHES AUDIENCES ACROSS THE GLOBE. HERE'S A SELECTION OF PUBLICATIONS AND ARTICLES BY BU SARGENT COLLEGE FACULTY IN 2018–2019.

Awad, L. N., Reisman, D. S., and Binder-Macleod, S. A. (2019). Distance-induced changes in walking speed after stroke: Relationship to community walking activity. *Journal of Neurologic Physical Therapy*. (In Press)

Awad, L. N., Malcolm, P., and **Walsh, C. J.** (2019). Soft wearable robots. *Wearable Robotics for Motion Assistance and Rehabilitation*. New York: Springer Publishing.

Brown, L. E. and **Camarinos, J.** (2019). The role of physical therapy in pediatric concussion rehabilitation. *"Concussion in Children" for Seminars of Pediatric Neurology*. (In Press)

Dalton, D. (2019). The vertebral column. *Joint Structure and Function; A Comprehensive Analysis,* (6th ed.), 108–162. Philadelphia: F.A. Davis.

Driscoll, L. and **Riley, E.** (2018). Assistive devices, adaptive equipment, orthotics, and wheeled mobility for the older adult. *Academy of Geriatric Physical Therapy Independent Home Study Course*.

Porciuncula, F., Nuckols, R., Karavas, N., Chang, C. K., Baker, T. C., Orzel, D., Perry, D., **Ellis, T.**, **Awad, L. N.**, and **Walsh, C. J.** (2019). Assisting limb advancement during walking after stroke using a wearable soft hip exosuit: a proof-of-concept. *Converging Clinical and Engineering Research on Neurorehabilitation III*. ICNR 2018. *Biosystems and Biorobotics* (21). New York, Springer.

Bae, J., Siviy, C., Rouleau, M., Menard, N., ODonnell, K., Galiana, I., Athanassiu, M., Ryan, D., Bibeau, C., Sloot, L., Kudzia, P., **Ellis, T. D., Awad, L. N.**, and **Walsh, C. J.** (2018). A lightweight and efficient portable soft exosuit for paretic ankle assistance in walking after stroke. *Robotics and Automation (ICRA)*, IEEE International Conference.

Ellis, T. D., Cavanaugh, J. T., **DeAngelis, T. R.**, Hendron, K., Thomas, C. A., Saint-Hilaire, M., and Latham, N. (2019). Comparative effectiveness of mHealth supported exercise compared to exercise alone for people with Parkinson Disease: randomized controlled pilot study. *Physical Therapy*, 2:99:203–216.

Pandit, S., Tran, S., Yiwen, G., Saraee, E., Jansen, F., Singh, S., Cao, S., Sadeghi, A., Shandelman, E., **Ellis, T.**, and Betke, M. (2019). ExerciseCheck: A scalable platform for remote physical therapy deployed as a hybrid desktop and web application. 12th International Conference on Pervasive Technologies Related to Assistive Environments (PETRA); Rhodes, Greece; June, 2019.

Holmes, M. B., Driscoll, L., Murphy, E., and **Starr, J.** (2019). A cross-sectional study of empathy in doctor of physical therapy students at two programs in Boston. *Journal of Allied Health*. (In Press)

Porciuncula, F., Roto, A. V., **Kumar, D.**, Davis, I., Roy, S., **Walsh, C. J.**, and **Awad, L. N.** (2018). Wearable movement sensors for rehabilitation: A focused review of technological and clinical advances. *Physical Medicine and Rehabilitation Journal*. 10S220–S232. PMID: 30269807.

Lewis, C. L., Khuu, A., and **Loverro, K. L.** (2018). Gait alterations in femoroacetabular impingement syndrome differ by sex. *Journal of Orthopaedic & Sports Physical Therapy*, 208; 48(8):649–658. doi: 10.2519/jospt.2018.7913.

Loverro, K. L., Khuu, A., Kao, P. C., and **Lewis, C. L.** (2019). Kinematic variability and local dynamic stability of gait in individuals with hip pain and a history of developmental dysplasia. *Gait & Posture*, 68:545–554. doi: 10.1016/j.gaitpost.2019.01.007.

Warner, M. B., Wilson, D. A., Herrington, L., Dixon, S., Power, C., Jones, R., Heller, M. O., Carden, P., and **Lewis, C. L.** (2019). A systematic review of the discriminating biomechanical parameters during the single leg squat. *Physical Therapy in Sport*, 2019;36:78–91. doi: 10.1016/j.ptsp.2019.01.007.

Sullivan, S., Hutchinson, I., Curry, E., **Marinko, L.**, and Li, X. (2019). Surgical management of type II superior labrum anterior posterior (SLAP) lesions: A review of outcomes and prognostic indicators. *The Physician and Sportsmedicine*. doi: 10.1080/00913847.2019.1607601.

Marinko, L. N. (2019). Posture. In: Levangie, P. K., Norkin, C., and Lewek, M. D. *Joint structure and function; A comprehensive analysis,* (6th ed.). Philadelphia: F.A. Davis.

Brown, K. S., Allopenna, P. D., Hunt, W. R., Steiner, R., **Saltzman, E.**, McRae, K., and Magnuson, J. S. (2018). Universal features in phonological neighbor networks. *Entropy*, 20(7):526. doi:10.3390/e20070526.

Nalepka, P., Lamb, M., Kallen, R., Shockley, K., Chemero, A., **Saltzman, E.**, and Richardson, M.J. (2019). Human social-motor solutions for human-machine interaction in dynamical task contexts. *Proceedings of the National Academy of Sciences of the United States of America* (PNAS), 116(4):1437–1446. doi.org/10.1073/pnas.1813164116.

Starr, J. (2019). Chronic pulmonary dysfunction. In O'Sullivan, S., and Schmidt, T. *Physical rehabilitation: Assessment and treatment* (6th ed.) Philadelphia: F.A. Davis.

Starr, J. and **Dalton, D.** (2019). The thorax and chest wall. In: Levangie, P. K., Norkin, C., and Lewek, M. D. *Joint structure and function; A comprehensive analysis*, (6th ed.), 163–179. Philadelphia: F.A. Davis.

Rodrigues, J., Norman, J., and **Starr, J.** (2019). American Physical Therapy Association: Description of specialty practice; Cardiovascular and pulmonary physical therapy. Alexandria VA.

Graber, T. G., Fandrey, K. R., and **Thompson, L. V.** (2019). Novel individualized power training protocol preserves physical function in adult and older mice. *Geroscience*. doi: 10.1007/s11357-019-00069-z. [Epub ahead of print] PMID: 31076998.

Kim, J. H., Graber, T. G., Liu, H., Asakura, A., and **Thompson, L. V.** (2019). Increasing myosin light chain 3f (MLC3f) protects against a decline in contractile velocity. *PLoS One*, 14(4):e0214982. doi: 10.1371/journal.pone.0214982.

Kwak, D., Baumann, C. W., and **Thompson, L. V.** (2019). Identifying characteristics of frailty in female mice using a phenotype assessment tool. *Journals of Gerontology*, Biol Sci Med Sci., pii: glz092. doi: 10.1093/Gerona/glz092.

Liu, H., and **Thompson, L. V.** (2019). Skeletal muscle denervation investigations: Selecting an experimental control wisely. *American Journal of Physiology-Cell Physiology*. 316(3):C456–C461. doi: 10.1152/ajpcell.0044102018. Epub PMID: 30624984.

Grant Awards

BU SARGENT COLLEGE'S PT FACULTY RECEIVED $1,886,233 IN RESEARCH FUNDING IN 2018–2019. HERE IS A LIST OF OUR PROJECTS AND THE AGENCIES AND FOUNDATIONS SUPPORTING PT RESEARCH.

SARGENT INVESTIGATOR	TITLE OF PROJECT	AGENCY/FOUNDATION	FUNDS AWARDED 2018–2019	YEAR OF AWARD	TOTAL AWARD
Louis Awad, assistant professor of physical therapy & athletic training	A Multi-site, Interventional, Non-comparative, Single-arm Trial to Evaluate the Safety of the ReWalk Restore Device in Subjects with Mobility Impairments Due to Ischemic or Hemorrhagic Stroke	ReWalk Robotics, Inc.	$38,952	1 of 1	$38,952
	Feasibility and Preliminary Effects on Post-stroke Locomotion of a Music-Modulating Wearable Sensor System	MedRhythms Inc.	$6,290	1 of 2	$12,582
	Multi-Modal Evaluation of Walking Function after Stroke	Boston University Clinical & Translational Science Institute	$15,000	1 of 1	$15,000
	Development of Stroke and MS Specific Soft Exosuits-Billing Agreement	ReWalk Robotics, Inc. subcontract via Harvard Wyss Institute	$34,478	2 of 2	$34,478
	Task Aware Movement Assessment: Smart Control of Powered Assistive Technologies and Automated Diagnostic Testing	American Heart Association	$99,995	1 of 2	$200,000
	Robotic Exosuit Augmented Locomotion (REAL) Training in the Clinic and Community	American Heart Association	$99,997	1 of 3	$299,973
Louis Awad and Anna Roto, doctoral student	Soft Robotic Exercise Intervention for Enhancing Neuroplasticity After Stroke	American Heart Association	$26,844	1 of 2	$53,688
Terry Ellis, associate professor and chair of physical therapy & athletic training	Walking and mHealth to Increase Participation in Parkinson Disease (WHIP-PD)	NIH/NICHHD	$681,818	1 of 5	$3,506,222
	Translation of In-Clinic Gains in Daily Life After Stroke	NIH subcontract via Washington University	$53,716	3 of 5	$241,289
	CPS: TTP Option: Synergy: Human Machine Interaction with Mobility Enhancing Soft Exosuits	NSF subcontract via Harvard Wyss Institute	$100,299	5 of 5	$328,801
	Development of a Modular Soft Exosuit Platform Suitable for Community-Based Neurorehabilitation	NIH subcontract via Harvard Wyss Institute	$125,323	4 of 5	$517,587
	Observational Study of Parkinson's Patients Using Radio Signals	Michael J. Fox Foundation subcontract via Massachusetts Institute of Technology	$50,000	1 of 1	$50,000
	CPS: TTP Option: Medium: Robotic Apparel to Enable Low Force Haptic Cueing for Improving Parkinson's Gait	NIH subcontract via Harvard Wyss Institute	$61,444	1 of 3	$194,530
	Robotic Exosuit Augmented Locomotion (REAL) Training in the Clinic and Community	American Heart Association subcontract via Harvard Wyss Institute	$44,530	1 of 3	$44,530
Deepak Kumar, assistant professor of physical therapy & athletic training	Mind Your Walk Intervention for Community-Based Management of Knee OA: A Feasibility Study	NIH/NIAMSD	$124,462	2 of 5	$622,311
Cara L. Lewis, associate professor of physical therapy & athletic training	Effect of Femoroacetabular Impingement (FAI) on Hip Motion in Young Adults	NIH/NIAMS	$158,890	5 of 5	$653,400
	Movement Screening and Modification in Individuals with Femoroacetabular Impingement Syndrome	NIH/NIAMSD	$82,500	2 of 2	$164,916
	Lower Extremity Movement Screening in Individuals with Musculoskeletal Hip Pain	Boston University Clinical & Translational Science Institute	$19,820	1 of 1	$19,820
Elliot Saltzman, associate professor of physical therapy	Modeling the Behavioral Dynamics of Social Coordination and Joint Action	NIH/NIGMS subaward via University of Cincinnati	$24,900	5 of 5	$124,500
	Collaborative Research: Prosodic Structure: An Integrated Empirical and Modeling Investigation	NSF	$14,975	2 of 3	$45,994
LaDora Thompson, professor of physical therapy & athletic training	A Preclinical Approach for the Enhancement of Quality of Life in Patients with Duchenne Muscular Dystrophy	Hanyang University/ National Research Foundation of Korea	$22,000	3 of 3	$66,000
TOTAL			**$1,886,233**		**$7,234,574**

Physical Therapy

FACULTY

Louis Awad Assistant Professor

Lisa Brown Clinical Assistant Professor

Diane Dalton Clinical Associate Professor

Laura Driscoll Clinical Assistant Professor

Terry Ellis Associate Professor and Chair

Diane Heislein Clinical Associate Professor and Director, Physical Therapy Programs

Mary Beth Holmes Clinical Assistant Professor

Karen Hutchinson Clinical Associate Professor

Dara L'Italien Lecturer

Deepak Kumar Assistant Professor

Cara Lewis Associate Professor

Lee Marinko Clinical Associate Professor

Erin Riley Clinical Assistant Professor

Elliot Saltzman Associate Professor

Julie Starr Clinical Associate Professor

LaDora Thompson Travis M. Roy Professor

AFFILIATED FACULTY

Paolo Bonato Adjunct Associate Professor

Sorcha Martin Instructor

Amy Pasternak Instructor

Serge Roy Adjunct Research Professor

Daniel Sieczkiewicz Instructor

Conor Walsh Adjunct Associate Professor

ABOUT SARGENT

Boston University College of Health & Rehabilitation Sciences: Sargent College has been defining healthcare leadership for nearly 140 years. As knowledge about health and rehabilitation increases and society's healthcare needs become more complex, BU Sargent College continuously improves its degree programs to meet the needs of future health professionals. Our learning environment fosters the values, effective communication, and clinical skills that distinguish outstanding health professionals. Our curricula also include an important clinical education component, providing students in every degree program with substantive clinical experience. Physical Therapy clinical experiences are available at more than 500 sites across the country. The college also operates outpatient rehabilitation centers that offer a full range of services to the greater Boston community.

To keep up to date on Sargent news and events, visit **bu.edu/sargent**

PROGRAMS OF STUDY

Doctor of Physical Therapy

Combined BS in Health Studies and Doctor of Physical Therapy

PhD in Rehabilitation Sciences

Combined Doctor of Physical Therapy and PhD in Rehabilitation Sciences

Fellowship in Orthopaedic Manual Physical Therapy

Neurologic Physical Therapy Residency Program

AWARDS & HONORS

- **Terry Ellis** received the Chattanooga Research Award from the American Physical Therapy Association, for the second time, in 2016, and received the 2019 Neurologic Research Award from the Academy of Neurologic Physical Therapy.
- **Diane Heislein** was elected to a three-year term on the Nominating Committee of The American Council of Academic Physical Therapy (ACAPT).
- **Deepak Kumar** received the 2018 Eugene Michels New Investigator Award.
- **Cara Lewis** received a 2016 Eugene Michels New Investigator Award from the American Physical Therapy Association, the 2017 Biomechanics Early Career Investigator Award from the APTA Biomechanics Special Interest Group, and a 2018 APTA Section on Research Traveling Fellows Award.
- **Julie Ann Starr** delivered the 2016 Linda Crane Memorial Lecture at the American Physical Therapy Association Combined Sections Meeting, and was named a 2019 Catherine Worthingham Fellow of the American Physical Therapy Association.
- **LaDora V. Thompson** was named the inaugural Travis Roy Endowed Professor, a unique opportunity to translate basic research to clinical application, and to collaborate with other scientists, students, and patients to improve the lives of people with spinal cord injuries and other disabilities.
- **Conor Walsh** received the Presidential Early Career Award for Scientists and Engineers.

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& Rehabilitation Sciences: Sargent College

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