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LOWER EXTREMITY REVIEW

April 20 / volume 12 / number 4

COVID-19

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Lower Extremity Review

Lower Extremity Review informs healthcare practitioners on current developments in the diagnosis, treatment, and prevention of lower extremity injuries. LER encourages a collaborative multidisciplinary clinical approach with an emphasis on functional outcomes and evidence-based medicine. LER is published monthly, except for a combined November/December issue and an additional special issue in December, by Lower Extremity Review, LLC.

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Lower Extremity Review Mission

Showcasing evidence and expertise across multiple medical disciplines to build, preserve, and restore function of the lower extremity from pediatrics to geriatrics.

EDITORIAL PILLARS

- Biomechanics matter
- Diabetic foot ulcers can be prevented
- Injury prevention is possible
- Collaborative care leads to better outcomes

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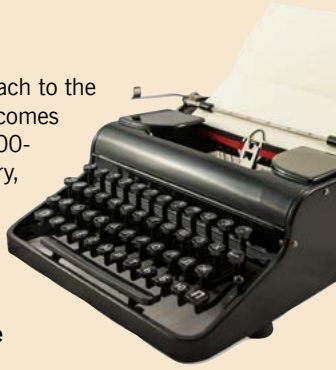
INFORMATION FOR AUTHORS

LER encourages a collaborative multidisciplinary clinical approach to the care of the lower extremity with an emphasis on functional outcomes using evidence-based medicine. We welcome manuscripts (1000-2000 words) that cross the clinical spectrum, including podiatry, orthopedics and sports medicine, physical medicine and rehabilitation, biomechanics, obesity, wound management, physical and occupational therapy, athletic training, orthotics and prosthetics, and pedorthics.



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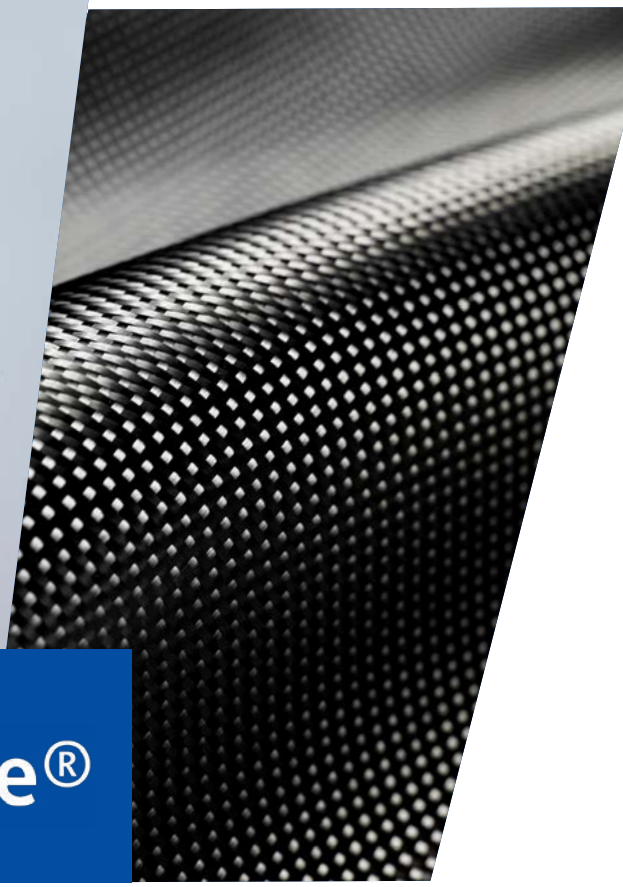

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Guest Editorial

Unique Times, Unique Opportunities

By Rich Dubin, Publisher, and Janice T. Radak, Editor, LER

We are living in an exceptional time. Like you, we're sheltering in our homes and donning face masks when we venture out. We're happy to play our part to prevent the spread of the novel coronavirus that leads to COVID-19, but we'll sure be happier when things return to normal…. But the reality is that there will be a new normal, and we can't quite see what that looks like just yet.

But working through this pandemic offers unique opportunities; although it might seem crazy, we're moving full steam ahead with plans we made to go boldly into 2020. In January, we published our new Mission Statement and the 4 editorial pillars that will support it (see page 11). Now, we're pleased to announce the addition of 4 members to the *LER* Editorial Advisory Board:

- **David G. Armstrong, DPM, MD, PhD**, Director of the Southwestern Academic Limb Salvage Alliance (SALSA) at the University of Southern California
- **Windy Cole, DPM**, Director of Wound Care Research at the Kent State University College of Podiatric Medicine
- **Paul DeVita, PhD**, Director of the Biomechanics Laboratory at East Carolina University
- **Bijan Najafi, PhD**, Director of the interdisciplinary Consortium on Advanced Motion Performance (iCAMP) at Baylor College of Medicine.

Our goal in adding these expert clinicians, researchers, and academics? To strengthen our medical education content and provide new perspectives that focus on how collaborative care improves outcomes—ie, building awareness that, by working together across disciplines, you and your peers and colleagues can do far more than you can alone. The COVID-19 lockdown/quarantine/sheltering-in-place—whatever you choose to call it—is certainly showing how that's true. And it's also showing us that there are new ways of delivering and receiving healthcare. Keeping up the flow of accurate information about current therapies and evidence-based practices is critical in times like these.

That leads us to our next piece of news.

We would like to introduce you to **LERexpo.com**—the first Global Community for Online Education focused on the lower-extremity. Like the print and online publication *LER*, the Community will be multidisciplinary, embracing Podiatry, Orthopedics, Physical Therapy, O&P, Pedorthics, Chiropractic, Athletic Training, and Wound Care. Our platform will allow online presentations with speakers able to gauge audience attitude; panel discussions; "fireside chats" for small groups; a cocktail party for all attendees (think: Speed Networking, facilitated by interests you've preselected); and interactivity with select advertisers who understand what clinicians need to know about their products. It will be a special experience for these exceptional times.

"The key is in not spending time, but in investing it."

Stephen R. Covey

Continued on page 10

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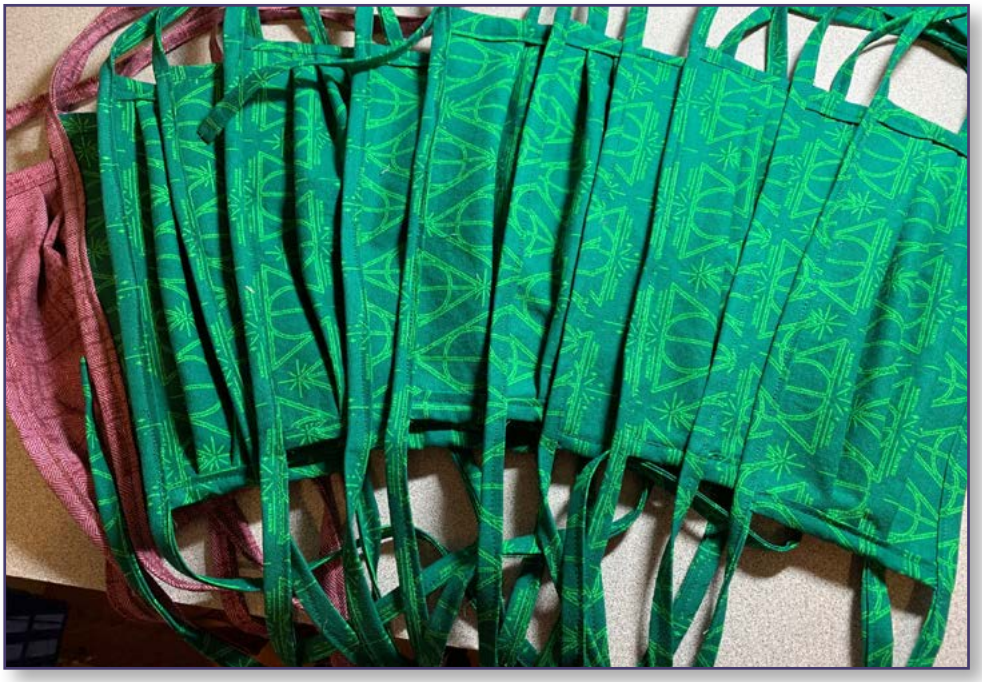
This might seem an unconventional time to start a new venture, but *LER* knows about tough times. We launched the publication in July 2009—during what has come to be known as the Great Recession. We were able to overcome a downturn in the economy—one that, importantly, didn't last forever—and provide our readers and advertisers with a new and trusted resource. Ten years later, we're facing challenges again—and, once again, *LER* wants to be there for you.

A decade ago, *LER* debuted at what everyone said was a terrible time to undertake a new endeavor. Now, we invite you to join us on another adventure—a multidisciplinary, multi-voice Community of learning with a single purpose: better outcomes for your patients.

Supporting the Cause



LER Editor Janice T. Radak is investing her pandemic time sewing 100% cotton face masks for family, friends, colleagues, the warehouse drivers at her daughter's medical device company, and local hospitals. (Harry Potter aficionados: Yes, those green masks show the Deathly Hallows.)

CALL FOR MANUSCRIPTS

The Editors of *Lower Extremity Review* want to highlight the work of thoughtful, innovative practitioners who have solved their patients' vexing problems. We are seeking reports of your most intriguing cases in the following areas:

- Biomechanics
- Falls and other injury prevention
- Prevention of diabetic foot ulcers
- Collaborative care

Before you begin to write, query the Editors about your proposed topic (email is fine). Doing so ensures that your manuscript will conform to the mission of the publication and that the topic does not duplicate an article already accepted for publication. Furthermore, a query often allows the Editors and the publication's advisors to make recommendations for improving the utility of the manuscript for readers.

Case reports should be no more than 1500 words (not including references, legends, and author biographies). Photos (≤4) are encouraged. Case reports can include a literature review as is appropriate for the topic. (Please note that for HIPPA compliance, photos should be de-identified before sending.)

Manuscripts must be original and not under consideration for publication elsewhere. Any prior publication of material must be explained in a cover letter.

All authors must be medical professionals in good standing. Students will be considered as first author only when the byline includes a fully licensed professional.

Manuscripts are submitted with the understanding that they will be reviewed; that revisions of content might be requested; and that the editorial staff will undertake editing, as necessary, aimed at improving clarity and conciseness and applying conformity to style. Authors will have the opportunity to review and approve the edited version of their work before publication.

The Editors reserve the right to reject any unsolicited or solicited article that does not meet with editorial approval, including approval denied following requested revision.

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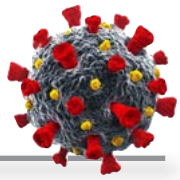

COVID-19: How The Virus Spreads, Unique Clotting, New Registries

On March 11, 2020, the World Health Organization (WHO) characterized infection by COVID-19, caused by the severe acute respiratory syndrome coronavirus (SARS-COV-2), as a pandemic. Worldwide, countries have issued stay-at-home orders of varying degrees, in an effort to stem the spread of the virus and "flatten the curve" on its rising death toll, as well as to prevent the collapse of healthcare systems globally. In response to the profound economic fallout, some countries have slowly begun to reopen. With no vaccine available and limited understanding of the disease itself, the question asked by public health experts is not when the second wave will strike but: *How lethal is this virus?*

SARS-COV-2 is a novel coronavirus; the human physiologic response has been difficult to tease apart in the rush to save lives. Research is underway on multiple fronts in the search for appropriate testing methods, treatment options, vaccines, and basic clinical care. This is an evolving situation; every day, we learn more about how the virus spreads and its impact on the human body. Here's a quick recap what we know so far and what's being done to move things forward.

Person-to-person Spread

According to the US Centers for Disease Control and Prevention, COVID-19 is thought to spread mainly through close, person-to-person contact from respiratory droplets. Unlike prior human contact with coronaviruses—SARS and MERS (Middle East Respiratory Syndrome)—COVID-19 is more easily transmitted, and might even be transmitted by asymptomatic or presymptomatic people. That means people who don't know they are infected could be infecting others as they go about their daily activities, which is why social distancing is a crucial part of the strategy to combat the spread of the virus. New guidelines about the need to wear a mask are also part of the strategy.

It appears that SARS-COV-2 is spreading easily and sustainably between people. Data collected from numerous countries suggest that this virus is spreading more efficiently than influenza, although not as efficiently as measles, which is highly contagious.

Because COVID-19 is a new disease, information regarding risk factors for severe illness is limited. Based on available information and clinical expertise, older adults and people of any age who have any one or more of several serious underlying medical conditions might be at higher risk of severe illness. Key underlying conditions that raise that risk include cardiovascular disease, diabetes, chronic lung disease, chronic kidney disease treated with dialysis, and liver disease. This list is preliminary, however, and is undergoing constant refinement. Although asthma was included on the original list, it has fallen off; at press time, increased scrutiny is on cardiovascular disease.

"Unique Clotting"

While the respiratory symptoms of COVID-19 infection are well known, other significant disease manifestations are coming to light as the pandemic continues and more people are infected—and, sadly, as more autopsies are completed. As Deborah Birx, MD, US Global AIDS Coordinator and a key leader on the US Coronavirus Task Force, told CNN's Jake Tapper on April 24, 2020, there are "unique clotting" issues associated with COVID-19 infection that need investigation.

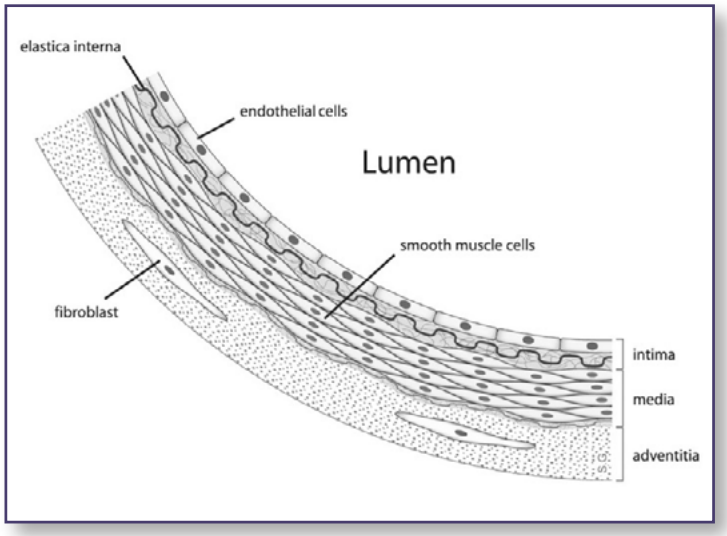

Figure 1. Vertical section of arterial wall reveals the location of endothelial cells. Image courtesy of DRosenback at English Wikipedia CC BY SA 3.0.

The clotting problem has been reported anecdotally to date, but new studies are emerging daily about the impact of COVID-19 on the peripheral vascular system, which is of particular importance to *LER* readers.

Writing in *The Lancet Online First*, Varga and global colleagues described endothelial-cell involvement across vascular beds of various organs in multiple patients with COVID-19 infection. They found evidence of viral infection of endothelial cells and diffuse endothelial inflammation, which can result in systemic endothelial dysfunction. Such dysfunction is "a principal determinant of microvascular dysfunction by shifting the vascular equilibrium toward more vasoconstriction with subsequent organ ischemia, inflammation with associated tissue edema, and a pro-coagulant state."

Varga goes on to say:

Our findings show the presence of viral elements within endothelial cells and an accumulation of inflammatory cells, with evidence of

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endothelial and inflammatory cell death. These findings suggest that SARS-CoV-2 infection facilitates the induction of endotheliitis in several organs as a direct consequence of viral involvement (as noted with presence of viral bodies) and of the host inflammatory response. In addition, induction of apoptosis and pyroptosis might have an important role in endothelial cell injury in patients with COVID-19. COVID-19-endotheliitis could explain the systemic impaired microcirculatory function in different vascular beds and their clinical sequelae in patients with COVID-19. This hypothesis provides a rationale for therapies to stabilize the endothelium while tackling viral replication, particularly with anti-inflammatory anti-cytokine drugs, ACE inhibitors, and statins. This strategy could be particularly relevant for vulnerable patients with pre-existing endothelial dysfunction, which is associated with male sex, smoking, hypertension, diabetes, obesity, and established cardiovascular disease, all of which are associated with adverse outcomes in COVID-19.

Clinical Observations

Scattered reports suggest early manifestations of COVID-19 infection occur in the peripheral limbs and, in particular, in the feet of children and young people (median age, 13 years) prior to the appearance of other symptoms. In a recent commentary in the *International Journal of Dermatology*, Landa and colleagues explained that these chilblain-like lesions include erythematous and papular lesions, acral lesions with crusting, and erythematous-violaceous lesions. Patients might describe them as rash, redness, irritation, or bruising. These skin issues can be painless or painful and can itch or cause burning. Timing of the appearance of these skin manifestations is uncertain: some case reports, such as Landa, cite these as post-COVID-19 infection whereas others report they appear pre-diagnostically or in asymptomatic patients.

Figure 2. The toes and heel of a 13-year-old boy with unique skin manifestations 2 days before he was given a diagnosis of COVID-19 infection. Images courtesy of Francesco Mazzotta and COVIDFootRegistry.com.

Figure 3. Left: Heel of a COVID-19-positive 30-year-old. **Right:** Toes of a 16-year-old who had 2 family members who tested positive for COVID-19 7 days earlier. Images courtesy of Maria del Mar Ruiz Herrera and COVIDFootRegistry.com.

Mazzotta, an Italian dermatologist, published one of the first cases of manifestations of COVID-19 infection in the feet with the International Federation of Podiatrists (availabe at https://www.fip-ifp.org/news/covid-19/). Disease occurred in a 13-year-old boy. He had skin manifestations on the foot prior to other symptoms of COVID-19 infection; 2 days after the photographs in Figure 2 were taken, the boy tested positive for COVID-19. Mazzotta provided these additional photographs, not published in his case study, to COVIDFootRegistry.com to alert clinicians to potential COVID-19 manifestations in the feet, prior to actual diagnosis.

Herrera, a podiatrist in Spain, shared photographs of 2 patients from her practice (see Figure 3). At left is the heel of a COVID-19-positive 30-year-old. At right are the toes of a 16-year-old who had 2 family members test positive for COVID-19 the week before onset of these skin manifestations.

COVID-19 Foot Registry

To facilitate understanding of the effects of COVID-19 infection on the feet, Michael Nirenberg, DPM, a forensic podiatrist, and a distinguished Expert Advisory Board have launched the COVID-19 Foot Registry. Available at COVIDFootRegistry.com, its mission is to gain insight into the signs and symptoms of COVID-19 in the feet and toes ("COVID toes"); its goal is to improve treatment and prevention of COVID-19 infection with the hope that this knowledge might be useful in addressing future viral disease outbreaks or recurrent COVID-type occurrences.

"In this unprecedented health crisis, all of us must do what we can," said Nirenberg, the registry's founder and director. "This Registry may, in a small way, lead to knowledge that helps us fight this disease. But, even if no relationship between COVID-19 and our feet is found, that may be useful to know too."

The registry is asking for photographs of skin manifestations in and information about persons who have, or might have, COVID-19 infection, which can be provided from physicians, podiatrists, dermatologists, healthcare workers, researchers and individuals, including patients. Submitters need to ensure their authority for submission and de-identification of any Protected Health Information (ie, submission must be HIPAA-compliant).

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Practical Triage for Lower Extremity Wounds During COVID-19 Pandemic

As the COVID-19 pandemic disrupts healthcare across the country, lower extremity clinicians will need to adapt to revised systems of care. In a Special Communication published in the Journal of the American Podiatric Medical Association, Lee C Rogers, DPM and 3 co-authors recommend the implementation of the following triage system for lower extremity wounds and diabetic foot problems.

	Conditions	Site of Care	Urgency
Critical (0.25% of patients with diabetes)	• IDSA Severe and some Moderate infections • Gas gangrene • SIRS/Sepsis • Acute limb-threatening ischemia	**Hospital**	**Priority 1** ***Urgent***
Serious (0.75% of patients with diabetes)	• IDSA Mild and some Moderate infections (including osteomyelitis) • Chronic limb-threatening ischemia (CLTI) • Dry gangrene • Worsening foot ulcers • Active Charcot foot	**Outpatient Clinic** **Office-based Lab** **Surgery Center** **Podiatrist Office**	**Priority 2**
Guarded (3% of patients with diabetes)	• Improving foot ulcer • Inactive Charcot foot (not yet in stable footwear)	**Podiatrist Office** **Home** **Telemedicine**	**Priority 3**
Stable (94% of patients with diabetes)	• Uncomplicated venous leg ulcers • Recently healed foot ulcer • Inactive Charcot foot (in stable footwear) • Diabetic foot risk assessments	**Home** **Telemedicine**	**Priority 4**

Source: Rogers LC, Lavery LA, Joseph WS, Armstrong DG. All feet on deck—the role of podiatry during the COVID-19 pandemic: Preventing hospitalizations in an overburdened healthcare system, reducing amputation and death in people with diabetes. JAPMA. 2020; https://doi.org/10.7547/20-051. Table used with permission of the American Podiatric Medical Association.

Among the specialists assisting in this effort is Congressman Brad Wenstrup, DPM. Wenstrup serves as the US Representative for Ohio's 2nd Congressional District and is one of only a few representatives in Congress with medical expertise. Other members of the Advisory Board include:

- Lawrence Harkless, DPM, interim dean at the University of Texas Rio Grande Valley's School of Podiatric Medicine
- David Armstrong, DPM, MD, PhD, professor of surgery and director of the Southwestern Academic Limb Salvage Alliance (SALSA) at the Keck School of Medicine at the University of Southern California
- Rock G. Positano, DPM, MSc, MPH, DSc, associate clinical professor of chronic disease epidemiology at the Yale School of Medicine at Yale University
- Bret Ribotsky, DPM, orthopedic surgeon; past president, American College of Foot & Ankle Orthopedics & Medicine; founder, DermFoot, LLC; and founder, Podiatric Success—Meet the Masters
- Marta I. Rendon, MD, international researcher and lecturer in dermatology; clinical associate professor at Florida Atlantic University, an affiliate of the University of Miami School of Medicine
- Marc Brenner, DPM, past president, American Society of Podiatric Dermatology

"We all need to work together to conquer this disease," said Brenner, who serves as chair of the Registry's Advisory Board. "I think we are going to find something important. Something that will make a difference. But we need the public's help." Brenner joined Nirenberg early in the project to create a registry, after he consulted on a young patient with odd skin lesions and suspected COVID-19 infection. He emphasized that some medical registries are accessible only by physicians but that, due the seriousness of COVID-19, this foot registry is accessible by anyone.

The Registry will collect data and information, and intends to publish and disseminate findings. The Advisory Board has volunteered its

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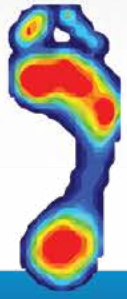

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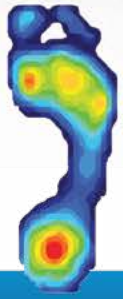

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Continued from page 17

time. The Registry is funded by Nirenberg's podiatry practice.

"I initially hoped the government or a big organization would put up a foot registry, but that wasn't happening. I didn't feel this should wait. This is too important."

Access to Medicare Telehealth Services Broadened Temporarily

With the emergence of the virus causing the disease known as coronavirus disease 2019 (COVID-19), there is an urgency to expand the use of technology to help people who need routine care, and keep vulnerable beneficiaries and beneficiaries with mild symptoms in their homes while maintaining access to the care they need. Limiting community spread of the virus, as well as limiting the exposure to other patients and staff members will slow viral spread. To this end, the Centers for Medicare & Medicaid Services (CMS) has broadened access to Medicare telehealth services so beneficiaries can receive a wider range of services from their doctors without having to travel to a healthcare facility.

These policy changes build on the regulatory flexibilities granted under President Trump's emergency declaration regarding the virus. CMS is expanding the access to Medicare telehealth services on a temporary and emergency basis pursuant to the waiver authority under section 1135(b)(8) of the Social Security Act and the Coronavirus Preparedness and Response Supplemental Appropriations Act. This benefit is part of the broader effort by CMS and the White House Task Force to ensure that all Americans—particularly those at high risk of complications from the virus—are aware of easy-to-use, accessible benefits that can help keep them healthy while helping to contain the community spread of this virus.

There are 3 main types of virtual services physicians and other healthcare professionals can provide to Medicare beneficiaries: Medicare telehealth visits, virtual check-ins, and e-visits.

Medicare Telehealth Visits:

- Starting March 6, 2020 and for the duration of the COVID-19 Public Health Emergency, Medicare will make payment for Medicare telehealth services furnished to patients in broader circumstances. These visits are considered the same as in-person visits and are paid at the same rate as regular, in-person visits.
- Starting March 6, 2020 and for the duration of the COVID-19 Public Health Emergency, Medicare will make payment for professional services furnished to beneficiaries in all areas of the country in all settings and for Medicare telehealth services furnished to beneficiaries in any healthcare facility and in their home.
- The Medicare coinsurance and deductible would generally apply to these services. However, the US Department of Health and Human Services (HHS) Office of Inspector General (OIG) is providing flexibility for healthcare providers to reduce or waive cost sharing for telehealth visits paid by federal healthcare programs.
- To the extent the waiver requires an established relationship, HHS will not conduct audits to ensure that such a prior relationship existed for claims submitted during this public health emergency.

Virtual Check-ins:

- Medicare will pay for virtual check-in services for established Medicare patients when the billing practice has an established relationship with the patient and where the communication is not related to a medical visit within the previous 7 days and does not lead to a medical visit within the next 24 hours (or soonest appointment available). The Medicare coinsurance and deductible would generally apply to these services.
- This is not limited to only rural settings or certain locations.
- The patient must verbally consent to receive virtual check-in services; however, practitioners may educate beneficiaries on the availability of the service prior to patient agreement.
- Virtual check-ins can be conducted with a broader range of communication methods (e.g., telephone discussion, text, email, patient portal, or video chat), unlike Medicare telehealth visits, which require audio and visual capabilities for real-time communication.

E-visits:

- Medicare will pay for established Medicare patients to have non-face-to-face patient-initiated communications with their doctors without going to the doctor's office by using online patient portals. These services can only be reported when the billing practice has an established relationship with the patient, and the Medicare coinsurance and deductible would generally apply to these services.

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- This is not limited to only rural settings. There are no geographic or location restrictions for these visits.
- The patient must generate the initial inquiry and communications can occur over a 7-day period; however, practitioners may educate beneficiaries on the availability of the service prior to patient initiation.

Furthermore, effective immediately, the HHS Office for Civil Rights will exercise enforcement discretion and waive penalties for HIPAA violations against healthcare providers who serve patients in good faith through everyday communications technologies, such as FaceTime or Skype, during the COVID-19 nationwide public health emergency.

For more information regarding this CMS announcement, including affected healthcare practitioners and appropriate billing codes, visit www.cms.gov/newsroom/fact-sheets/medicare-telemedicine-health-care-provider-fact-sheet. For more information regarding COVID-19 and HIPAA, visit www.hhs.gov/hipaa/for-professionals/special-topics/emergency-preparedness/index.html.

American Academy of Dermatology Registry

The American Academy of Dermatology has also begun a registry to focus on the dermatologic manifestations of the COVID-19 virus. Unlike the COVID Foot Registry, the AAD registry is only for healthcare professionals and is not limited to those specializing in dermatology. Professionals from any country may enter a case.

AAD is seeking several types of cases for inclusion:

- Patients with COVID-19 (confirmed or suspected) who develop dermatologic manifestations
- Patients with existing dermatologic conditions who subsequently develop COVID-19
- Patients on existing dermatologic medications who subsequently develop COVID-19

The case report form should take about 5-7 minutes to complete; registrants will be asked to provide their name, email address, and hospital. Patient information to be collected includes demographics, details about the patient's new onset dermatologic condition, past medical history including past dermatologic conditions and treatments, as well as details surrounding the patient's COVID-19 diagnosis and treatment. However, all of this detail is not required to enter the case and "Don't Know" is an answer option. As for COVID-19 diagnosis, "clinical suspicion only" will be among the answer options. The registry is not meant to affect patient care. The registry is simply meant to record events that have taken place.

Currently, there is no place to upload photos. If you indicate there is a photo that can be shared and you also indicate on the form that it is acceptable to contact you in conjunction with the case, they will contact

you about further collaboration. Some institutions may still require a data use agreement to share non-identifiable patient data; reach out to covidregistry@aad.org if this applies to you.

Patient identifiers such as name or date of birth will not be collected. All de-identified information will be kept strictly confidential and will only be shared with researchers compiling information. Data will be stored on a secure Redcap server at Massachusetts General Hospital (Partners Healthcare). Information and updates will be shared via the COVID-19 American Academy of Dermatology website.

If you are a patient who would like your case included, share the link www.aad.org/covidregistry with the person providing your care.

For more information, contact covidregistry@aad.org.

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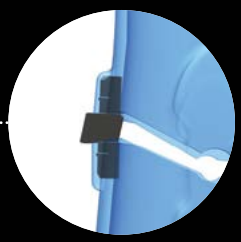

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Early Orthotic Intervention in Pediatric Patients, Part 3: Muscular Dystrophy

Improving patient care includes questioning traditional treatment approaches; in this case, it's also about developing ways to enhance and augment those techniques.

By Cary Groner

The first two articles in this series looked, respectively, at early orthotic intervention in children with cerebral palsy (CP)[1] and in those with Down syndrome and other neurological conditions.[2] In those cases, although there were predictable differences of professional opinion, a rough consensus emerged around treatment strategies and decisions.

Not so with muscular dystrophy. Most experts don't sanction the use of daytime ankle-foot orthoses (AFOs), and even nighttime wear is subject to debate. This article will explore these opinions, which are supported by evidence of varying strengths. It will also, however, examine an early orthotic intervention that has shown anecdotal promise in individual cases, and of which the clinical community may want to be aware.

Defining Terms

Muscular dystrophy comes in many forms, all of which are hereditary. The most common type is Duchenne muscular dystrophy (DMD), named for the French neurologist who first described it in the 1860s.[3]

DMD results from a genetic mutation that interferes with the production of a protein called dystrophin, which is necessary for maintaining healthy muscle tissue. Because the associated gene is found on the X chromosome, it is usually passed down by mothers to their sons; girls are protected by having two X chromosomes, only one of which needs to have a functioning gene for dystrophin production. Nevertheless, rare cases have been reported in girls (presumably if both X chromosomes contain the mutation), and roughly a quarter of cases arise spontaneously, with no known family history. The disease occurs in roughly 1 per 5,000 male children.[4]

Editor's Note: This article is sponsored by an educational grant from LaunchPad O&P and Orthotic Care.

Image courtesy of Orthotic Care Services and LaunchPad O&P

Children with DMD have symptoms that typically appear between the ages of 2 and 5 years, and may include delayed sitting, standing, walking, and trouble learning to speak. Other common problems are fatigue, gait abnormalities, frequent falls, lordosis, scoliosis, and contractures (the attenuation of muscles or tendons around joints). Muscle weakness begins proximally, in the hips, pelvis, and upper legs—as well as in the shoulders and upper arms—and the associated degeneration progresses distally and relentlessly. Many patients need motorized wheelchairs by their mid-teens.

Exercise can help maintain strength, but one discouraging aspect of DMD is that too much exercise—especially weight training—in the absence of dystrophin can lead to muscle breakdown that ultimately weakens the child.

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> "When I see these kids early enough in the course of the disease, I've been able to balance foot and ankle alignments and shank-to-vertical angles through stance phase, which enhances and assists during swing phase."
>
> **Scott Hinshon, CO**

DMD has no cure, but treatment can ameliorate some symptoms and prolong ambulation. And although promising new approaches include gene therapy, and the administration of corticosteroids to preserve muscle strength, the atrophy of skeletal, cardiac, and pulmonary muscles typically leads to death in patients' 20s or 30s.

As a result, pediatric neurologists, physical therapists, orthotists, and other specialists ideally work together to optimize patients' quality of life.[5] Exercise can help maintain strength, but one discouraging aspect of DMD is that too much exercise—especially weight training—in the absence of dystrophin can lead to muscle breakdown that ultimately weakens the child. As a result, exercise has to be carefully dosed, and the patient's strength and resilience closely monitored. Pool exercises and other approaches that minimize eccentric contractions are a common choice.

Clinicians also emphasize the importance of range of motion (ROM), either by stretching or the use of orthotics such as AFOs. It's in the latter realm that matters can become contentious.

The Argument Against

Eileen Fowler, PhD, PT, director of the Kameron Gait & Motion Analysis Laboratory in the UCLA Department of Orthopaedic Surgery, explained that most AFOs restrict ankle movement, which limits DMD patients' ability to compensate for their proximal weakness. As *LER* has reported before, compensatory gait patterns often allow such children to sustain ambulation, and interfering with those patterns can do more harm than good.[6]

"Ankle plantar flexors contract during toe walking to place the line of gravity closer to the hip and knee joints, decreasing the moments required at those proximal joints and preserving muscle strength," Fowler said. "When you restrict the ankle, it forces the knee into flexion so that the quadriceps are slowly controlling the lengthening of the muscles—an eccentric muscle contraction—and that's how they damage their muscles. So I think it's a bad idea to prescribe AFOs for young children with this condition. Sometimes the body is smarter than we are."

Fowler acknowledged that AFOs are appropriate for children with other neuromuscular disorders such as cerebral palsy. She also supports stretching regimens and the use of night bracing to prevent contractures, and has found that corticosteroid treatment can help patients maintain their ability to walk until they're older.[7]

"Some kids get foot deformities and walk on their toes with their foot in a terrible position," she said. "I know orthotists have tried to come up with ways to accommodate that, but I've never seen it work very well."

Bryan Malas, MHPE, CO, director of orthotics / prosthetics at the Ann and Robert Lurie Children's Memorial Hospital in Chicago, told *LER* that he and his colleagues feel much the same way.

"It would be rare for us to use an AFO in this patient population," he said. "We primarily use them for nocturnal wear in an attempt to maintain ankle range of motion and limit contractures."

That said, Malas admitted that there isn't enough data to arrive at decisions about dosing. "Is nighttime wear enough?" he asked. "Maybe it's not—maybe these kids need to wear something that will help prevent the loss of range of motion for a longer period of time."

Malas noted that because DMD patients have a progressive, terminal condition, they often have more on their plates than just concerns about ambulation.

"How critical is an AFO if they have to deal with all these other aspects of the disease?" he asked. "I don't know that you're going to have good compliance, or if you'll even be able to measure it. Even with nocturnal bracing, until we're able to quantify the amount of time these kids are actually wearing that orthosis, I think we're going to have arguments on both sides of the fence."

That said, Malas feels that ultimately ambulatory bracing isn't helpful.

"In most cases, AFOs are going to disrupt balance," he said. "That makes it harder for these kids to walk, which defeats the purpose. Ideally we want to keep them ambulating as long as possible."

Poor Data

Perhaps not surprisingly, the literature about orthotic treatment of children with DMD is inconclusive. For example, a literature review from 2000 reported that the studies at the time were relatively weak, and suggested that AFOs could prolong assisted walking and standing (vs.

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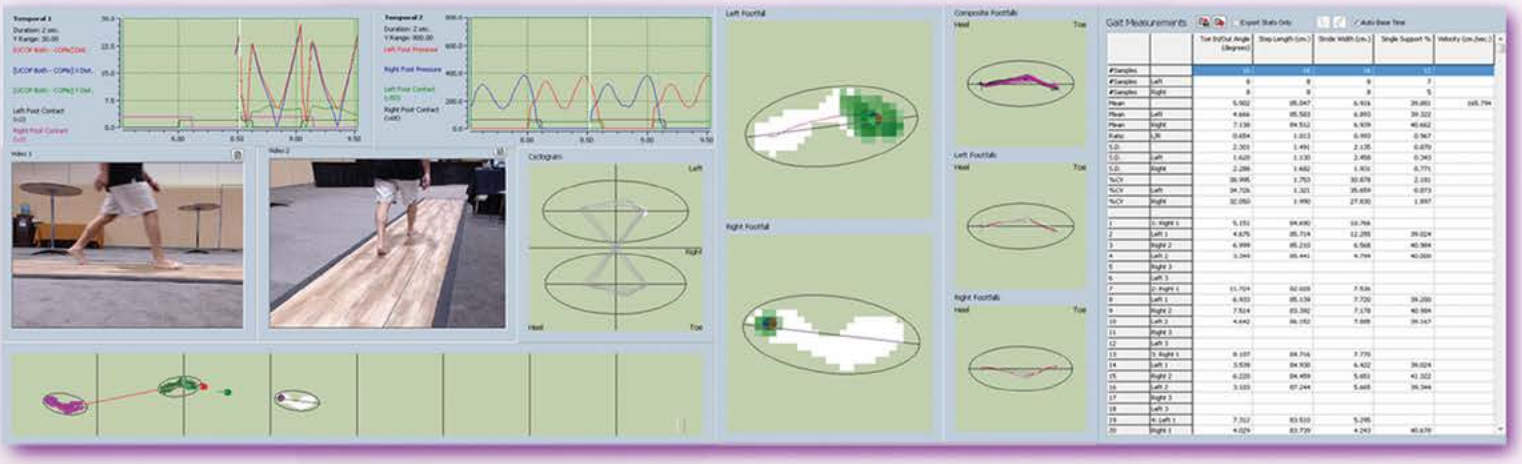

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The researchers noted that the typical DMD compensations—lumbar lordosis, increased anterior pelvic tilt, reduced hip extension, and increased ankle plantar flexion—tend to position the ground reaction force vector posterior to the hip and anterior to the knee, hence reducing the demand on weaker hip and knee extensors.

wheelchair use), but probably didn't prolong functional walking.[8] Similarly, a 2015 study found that dynamic response AFOs didn't significantly improve walking ability and might have increased falls—though the study included just 3 boys, lasted only 2 weeks (which raises questions about the time needed for the kids to adjust to the AFOs), and included a "placebo intervention" (it's hard to imagine how either subjects or researchers would have been blind to the placebo).

On the other side, a 2017 study from India followed 126 children for 4 years and reported that they ultimately "required" AFOs as resting or walking splints.[9] In the same vein, a Brazilian paper from 2016 studied 20 patients in 3 groups ("no orthosis," "night orthosis," or "day orthosis") for 5 to 7 months, and concluded that early daytime and nighttime use of articulated AFOs minimized compensations and was thus recommended to prolong gait ability.[10] This conclusion raises obvious questions, however, for as noted earlier, minimizing compensations may not be a sound strategy in these patients.

The quality of research, in other words, doesn't appear to have improved significantly in the two decades since the 2000 literature review found it wanting.

That said, a few papers have begun to shed light on the deeper biomechanics of the disease, and the strategies clinicians may use to address DMD. For example, in a study reported in Gait & Posture in 2016, researchers used 3D gait analysis to objectively quantify changes in lower extremity function due to muscle weakness.[11] The researchers noted that the typical DMD compensations—lumbar lordosis, increased anterior pelvic tilt, reduced hip extension, and increased ankle plantar flexion—tend to position the ground reaction force vector posterior to the hip and anterior to the knee, hence reducing the demand on weaker hip and knee extensors. They concluded that gait analysis can detect deficits in hip joint kinetics in young boys with DMD, as well as improvements following a corticosteroid intervention, and may be useful in evaluating future therapeutic interventions.

Perhaps the most comprehensive assessment of DMD rehabilitation and management was published in 2018, in Pediatrics, by researchers at Duke and several other universities.[12] Lead author Laura Case, PT, DPT, and her colleagues outlined a comprehensive approach to the disease that includes protecting muscles; maintaining strength; minimizing disease progression; supporting functional independence, social participation, and quality of life; and so forth. The paper includes a detailed pathokinesiology of DMD disease progression and concludes that resting or stretching AFOs—including nighttime bracing—are necessary to minimize plantarflexion contractures. The AFOs should be custom molded, fabricated for optimal foot–ankle alignment, and started when patients are young. If patients won't tolerate night braces, the authors recommend daytime stretching AFOs for use during nonambulatory periods or by those in wheelchairs. They don't recommend AFOs for ambulation, however, because they limit patients' compensatory movements and add weight.

Something New

It's easy to conclude from such evidence that daytime, ambulatory AFOs simply aren't appropriate for DMD patients. That's a little like saying "cars are dangerous," however; it depends on what kind of car you're talking about and who's driving it. If an ambulatory AFO could be designed that improved these patients' gait mechanics without increasing the eccentric load on their muscles, it could theoretically prove beneficial.

One such AFO exists, as it happens. It has been used sparingly by its inventor and the reports of its efficacy are anecdotal. Nevertheless, it appears promising and warrants discussion here.

Marilyn Ash is a 43-year-old homemaker in suburban Minneapolis. DMD runs in her family; her brother died of it in 2015. When her son, Tyler, was three and a half, he too was diagnosed with the disease, and Ash began looking for people who could treat him.

One of those was Scott Hinshon, CO, who is CEO of both Orthotic Care Services and LaunchPad O&P, a maker of orthotic devices in Minneapolis.

"Scott said we could put these dynamic boots on him and then every time he takes a step it's actually a stretch, and will increase his range of motion," Ash said. "Tyler started wearing them a couple of hours a day, and we noticed that his ROM was increasing."

That was 5 years ago, and Tyler still wears the AFOs about an hour a day. He sees Hinshon

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> "I think orthotics are being overlooked for DMD. It's a tricky balance, because if these patients are too active they get muscle wasting, but if you don't keep them mobile they're going to get contractures and deformities. So you're trying to prolong joint integrity..."
>
> **Carey Jinright, CO**

2 or 3 times a year for an assessment and to have the AFOs adjusted, and Ash said that now, at age 8, his ROM remains normal. He tolerates the AFOs well, runs around a lot, and doesn't fall. His neurologist, physiatrist, and pediatrician, she added, are skeptical.

"They're apprehensive that the weight of the AFO might be harmful to Tyler's muscles, but they're pretty light, and he wears them with lightweight tennis shoes," she said. "The funny thing is that they know how well he's doing, but they're reluctant to attribute it to that." (None of the physicians Ash recommended returned *LER*'s calls requesting comment.)

Ash thinks that part of the reason she's been able to keep Tyler up and running is that his relatively early diagnosis allowed the interventions to begin a year or two sooner than they typically would.

"When boys don't get diagnosed until they're 5 or older, by then they're falling, they've lost range of motion, they have contractures, and there's already been damage to their muscles," she said.

Scott Hinshon agrees that early intervention can be key in cases like Tyler's. He's aware of the generalized professional dislike of ambulatory bracing, but feels it may change when better information becomes available.

"All bracing isn't created equal," he told *LER*. "If your goal is to prolong mobility, then you also have to maintain range of motion and prevent deformity, while at the same time avoiding the fatigue that contributes to muscle wasting. It's a delicate balance."

Hinshon and his colleagues evaluate DMD patients thoroughly at every appointment and make adjustments to their treatment plans accordingly.

"You see a domino effect in these kids," he explained. "First weakness, then compensated gait, then contracture, then deformity. But if you have an opportunity to intervene early enough and normalize gait, you can sustain ROM and help prevent those irreversible physical consequences. Once deformity has progressed, ambulation becomes almost impossible and then there's little you can do to treat them. The kids start to choose not to walk because it's really difficult. There's no benefit to daytime ambulatory bracing if it doesn't provide a functional benefit."

Hinshon believes the resistance to ambulatory bracing is based partly on a misunderstanding of what AFOs can do.

"If I put these kids in a sold-ankle AFO with a traditional heel, it creates a fulcrum effect that negatively pushes and pulls the knee during stance phase," he said. "This creates a demand on proximal musculature, which is not what you want with DMD patients."

Instead, he's designed an AFO with a soft, flexible inner boot, combined with an articulated outer boot. The AFO includes an open cushioned heel that eliminates the fulcrum effect at heel strike. This approach, he said, helps control stance-phase rocker motion and eliminate push or pull on the knee. This is the AFO that Tyler Ash wears.

"When I see these kids early enough in the course of the disease, I've been able to balance foot and ankle alignments and shank-to-vertical angles through stance phase, which enhances and assists during swing phase," he said. "Normalizing step length and foot projection angles is key to sustaining dorsiflexion range."

Hinshon and his staff tune and finesse the design individually for each patient to optimize gait and prevent contracture and joint deformity.

Carey Jinright, CO, owner of Precision Medical Solutions in Montgomery and Auburn, AL, thinks the approach holds promise.

"I think orthotics are being overlooked for DMD," he said. "It's a tricky balance, because if these patients are too active they get muscle wasting, but if you don't keep them mobile they're going to get contractures and deformities. So you're trying to prolong joint integrity any way you can."

Jinright thinks that part of the problem is that pediatricians delay care decisions too long; as a result he often first sees patients when they're 9 or 10 years old—far too late for the early interventions Hinshon describes. Jinright had one such patient who could walk about 100 feet without problems, but then would invariably fatigue and fall. He was able to treat him successfully with carbon fiber AFOs and delay use of a powered wheelchair. Part of this strategy involved using elongated orthoses to increase the lever arm in the feet.

"You give them an effective foot length that matches their height and weight, and that provides better proximal balance," he said. "I've also found it can decrease their lordosis. If we could see them earlier, I think we could keep those proximal muscles more in the mix. And if we could see them often enough, we could work on keeping the fluidity of their gait cycle, and keep them ambulatory longer than they are now."

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Changing paradigms?

Hinshon admits that his approach remains controversial, but he figures that as more evidence becomes available, and further modifications are made, the design may gain acceptance.

"If nothing else comes of this than people start to consider it a viable alternative for early treatment, I'm fine with that," he said. "We know that traditional AFOs don't work in these kids, but if we can intervene early, and design AFOs with the right functional focus, I think we can treat them successfully."

Cary Groner is a freelance writer in the San Francisco Bay area.

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BY MARIANNE ADAMS, MA, MFA

Joseph Hubertus Pilates began development of his method – a body–mind approach to exercise –in the early 1920s. As a child, Pilates suffered from asthma, rickets, and rheumatic fever. His early efforts toward self-healing explored a multilayered approach to building strength, body awareness, breath control, and increasing flexibility, all in a balanced way.[1] Early in his career, he also worked as a boxer, circus performer, and self-defense trainer.

Because Pilates's perspectives were so varied, his approach makes Pilates particularly effective as a rehabilitative tool – recognizing the role that kinesthetic awareness, or mindfulness, plays in efficient physical (and mental) repatterning.[2] The Pilates method was designed to create harmony between body and mind by combining aspects of mental focus and breath awareness with the physicality of gymnastics and other sports.[3]

Between the 1920s and 1970s, an increasing number of dancers, circus performers, and athletes worked with Pilates and had a strong impact on the development of his method. To develop his method, Pilates studied, and drew from, Eastern and Western practices, including Yoga, Zen meditation, and ancient forms of Greek and Roman exercise. His original name for the Pilates method was "Contrology," which he defined this way[4]:

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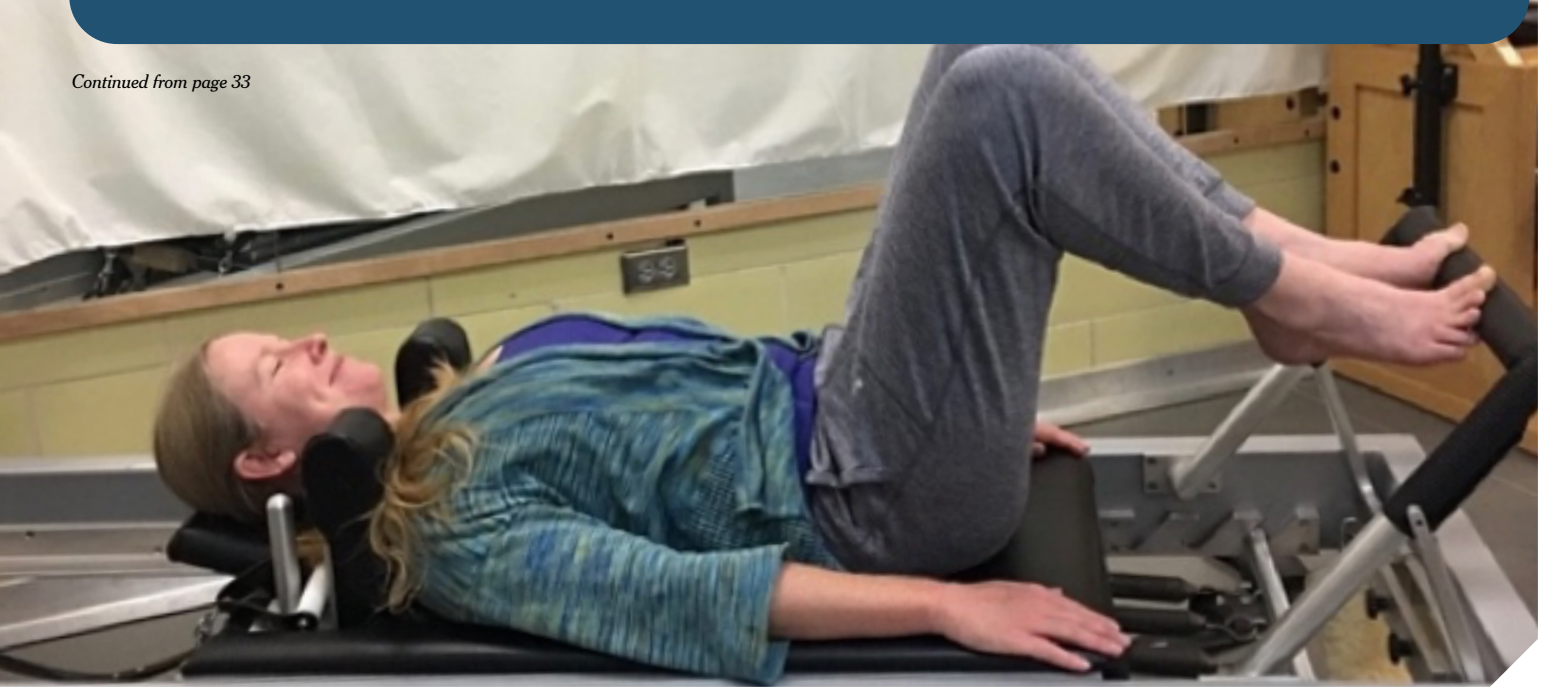

Figure 1. Footwork on the Reformer: Toes first
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Pilates's Method Today

Although there are many different approaches to the Pilates method, the style that adheres most closely to Pilates' original work is "Classical," or "Authentic," Pilates. In this tradition, the work is typically taught one-on-one, using equipment that is very similar to the equipment that Pilates developed in the early part of the 20th Century. Pilates created more than a dozen pieces of apparatus – using springs, pulleys, and arcs for resistance or support – to improve fitness on 3 levels: mind, body, and spirit.[5]

Although many clients might have been exposed to Pilates mat exercises, the full potential of the method is enhanced by experiencing the method in a fully equipped studio. Each lesson is individualized, and all teachers certified in the Classical approach have completed a rigorous training program more than 600 hours long, including comprehensive examinations.

Getting Started

Pilates created a repertoire of more than 500 exercises for supine, standing, and seated positions. Whereas one apparatus adds challenge, a similar exercise on another apparatus will give a beginner, or rehabilitative client, a needed simplification.[2] Although the examples provided in this article focus on exercises for strengthening, awareness of alignment, and increasing range of motion in the lower leg, the fundamental philosophical approach of the method is to "work" the body as a unified whole.

An important aspect of the Pilates method is to treat the whole body as a system; that is, clients who are seeking rehabilitation for a specific body condition are instructed to initiate and engage from the core of the trunk musculature, generally considered to include the transversus abdominis, oblique, rectus abdominis, gluteal, and adductor muscles. Pilates called this core the "powerhouse." The approach of working mindfully with the breath is central to his method, as is a limited number of repetitions with each exercise, to foster the sense of mind–body kinesthesia.

Footwork (Supine) Using the "Reformer"

This is the first piece of apparatus that Pilates invented, while interned as a German prisoner of war in England, during World War I. He made his early prototype from a hospital bed, using springs and pulleys, to help his platoon recover and heal from their injuries. The Reformer comprises a frame with springs that attach to a carriage. As the carriage rolls horizontally on tracks, the springs add non-weight-bearing resistance to each exercise.

Because most exercises on the Reformer, are performed supine, this is the typical starting place for most clients. Typically, the instructor stands at the foot of the Reformer as this position offers a trained instructor a wealth of information on full body alignment, muscular habits of tension, breath patterns, etc., as the client begins to move.

The initial series of exercises on the Reformer is called "footwork" (Figure 1). The client lies supine on the carriage, knees bent, with the metatarsal pads of the feet at the center of the foot bar, heels together, toes in external rotation at 30° to 45°. As the client straightens their legs, they push the carriage away from the foot bar; the springs add resistance. The spring action

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Figure 2. Working the Reformer with legs straight, feet parallel
For clients with hypermobility of the knee, all the Reformer exercises shown here (Figures 1-4) can be done without rotation, with feet parallel–together or 4 to 6 inches parallel apart.

Figure 3. Exercising the arches with the Reformer
The second footwork exercise on the Reformer stretches and strengthens the arch of the foot. The client moves the feet to parallel as the knees flex and straighten, moving the carriage out and in, while pushing the arches against the foot bar. Because the instructor stands at the foot of the Reformer, it is easy to spot alignment issues and asymmetrical muscular patterning in the calf, thigh, and abdominal regions.

Figure 4. Exercising the heels with the Reformer
The third footwork exercise includes pushing from the heels with legs in the parallel–together position. Attention is paid to activating the medial and lateral line of the legs by pulling the little toes towards the nose. Note: In each footwork exercise, the client is encouraged to widen the back of the ribs into the carriage, lift the abdominals in and up, and coordinate the outbreath with the muscular effort.

must be controlled on the return as the carriage glides back into the stop, or stable, position.

By pulling the transverse abdominal muscles in and upward, the legs push against the bar to straighten and, keeping the legs straight (Figure 2); the heels then lower and lift, working to increase strength and range of motion in the toes and ankle joint. For clients in the active rehab phase of an ankle or knee injury, or after hip replacement, the spring resistance typically is adjusted downward, from 4 to 2 springs.

Footwork is a multipart exercise, repeated in several foot positions, using the toes (Figure 1), arches (Figure 3), and heels (Figure 4) and a tendon stretch (Figure 5).

Footwork Seated in the "Wunda Chair"

Also known as the "magic chair," the Wunda Chair (Figure 6) was developed for Pilates's advanced clients who wanted a challenging workout in their home. The Wunda Chair comprises a stationary seat and a foot pedal; resistance varies with differing spring settings. Beginners will find many basic exercises on the Wunda Chair that increase strength, awareness of alignment, and balance. A client must be able to engage their abdominal core and balance while seated on a backless chair.

To complete the tendon stretch on the Wunda Chair (Figure 7), the client stands, with toes on the pedal in forward spinal flexion, as they lower and lift the heels by engaging the core muscles of the powerhouse. This is done on 2 legs simultaneously or in a right–left–right or left–right–left alternating pattern, as needed for rehabilitation.

In general, the Wunda Chair is good for working the weak–strong–weak sides of the body. It is important to realize that, although a client might present, for example, "a bad ankle," any injury is rarely so isolated. Particularly when working with clients in rehabilitation, an instructor who begins to look closely will see that the presenting ankle problem is often linked to other patterns of dysfunctional alignment. Injury in one particular place will often be related to weakness or overuse in another area of the body.

This is the real beauty of the Wunda Chair: After close examination, an instructor might realize that, although a client needs to do right–left–right repetitions of the tendon stretch, they in fact need a left–right–left exercise pattern for the hips and a right–left–right pattern for exercises to strengthen or stretch the quadratus muscles.

Footwork (Standing) With the "Foot Corrector"

This apparatus can help identify and solve problems in foot and ankle standing alignment (Figure 8). The device is also helpful for rehabilitation after lower-leg injury.

The Foot Corrector comprises a brass foot plate, 2 vertical springs, and a perpendicular cross-plate that moves downward as the springs are compressed. It is often used for dancers or climbers, who need articulate foot strength and acute balance sensitivity. Because postural alignment needs to be maintained (keeping iliac hip pointers even), careful placement of the apparatus in relation to the standing leg and a watchful eye by the instructor are needed for feedback (Figures 9-11).

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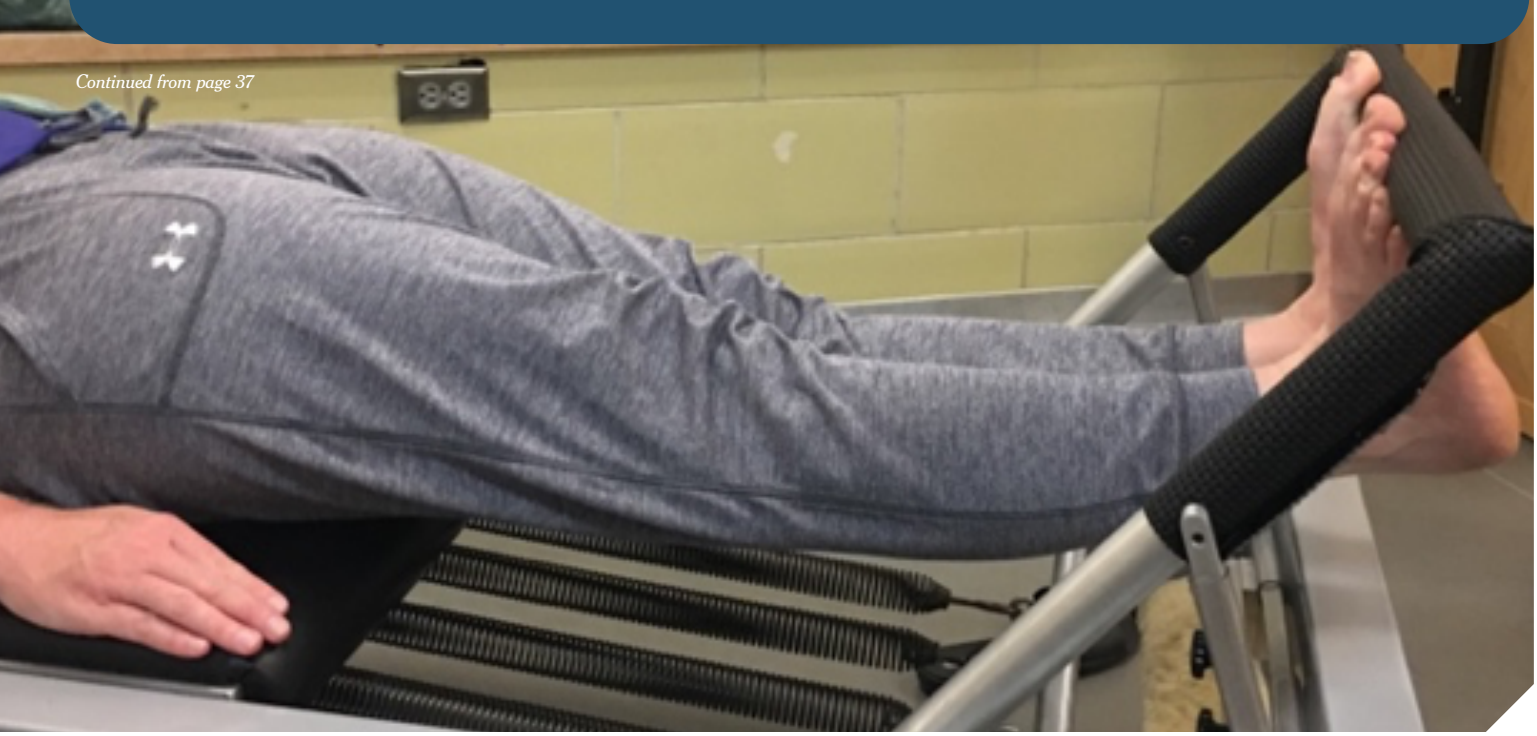

Figure 5. Stretching tendons with the Reformer
The final exercise of the footwork series is the tendon stretch, with the toes going back to the foot bar in the original externally rotated position (see Figure 1). While the legs stay straight, the heels lower and lift, stretching the Achilles tendon and stretching and strengthening the soleus and gastrocnemius muscles.

Toe Spacer

Rarely used, the toe spacer (Figure 12) is a small but beneficial piece of Joseph Pilates' inventive repertoire.

Multiple Benefits Using Multiple Techniques

These are only a few Pilates footwork exercises. Many others, on other equipment, are performed in a typical Classical lesson to work the body as a unified system. Together, the apparatus system offers a great deal of flexibility for clients with varied needs. For example, clients with less mobility might start on the "Trapeze Table" (also called the "Cadillac"), which can be described as a massage table with a canopy frame. This apparatus allows a client to begin their exercises that provide spring resistance in a stable, supine position.

When Pilates is practiced with a comprehensively trained professional, in a fully equipped studio, efficient progress can be made by increasing awareness of postural habits and alignment issues. For many clients, simply coordinating the conscious use of breath with movement initiation from the core eases pain and can improve daily quality of life. Consistent Pilates training can enhance alignment awareness, physical efficiency, and core control.

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Figure 6. The Wunda Chair
A somewhat more challenging variation of the footwork series can be performed while the client is seated atop the Wunda Chair. The client begins the footwork series working the toes, arches, and heels in a seated position.

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Figure 7. Wunda Chair tendon stretch
The tendon stretch can be completed in an externally rotated or parallel position, as needed for the individual client. With weight equally distributed on hands and feet, the core muscles of the powerhouse are challenged to help lower and lift the heels; doing so also activates and stretches the hamstrings and calf muscles.

Figure 8. The Trapeze Table offers stability when working the Foot Corrector
The client keeps their standing leg straight while holding a vertical pole on the Trapeze Table (also known as the "Cadillac") for stability. The client keeps the working knee bent while depressing the springs and returning with control, working toe articulation.

Figure 9. Working the arches with a Foot Corrector
When using the Foot Corrector to stretch and strengthen the arches, weight must be placed on the standing leg, which should be placed directly across from the apparatus, with attention to keeping the hips square and the iliac crests pointing anteriorly forward.

Figure 10. Foot Corrector: Heel pushes
When using the foot corrector apparatus to work through heel pushes, the heel must push against the resistance of strong springs. Working through the toes, arches, and heels while standing provides an opportunity to focus on foot articulation; additional balance support is provided by holding on to the frame of the Cadillac (see Figure 8).

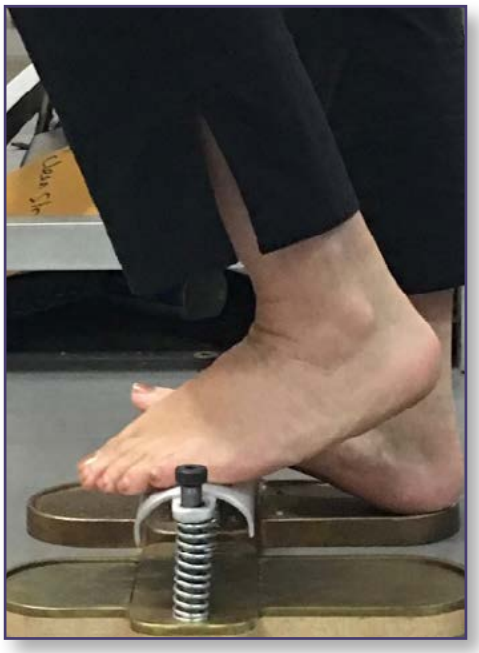

Figure 11. Foot Corrector: Tendon stretch exercise
This exercise can be practiced by alternating legs, using a pair of Foot Correctors. Advanced clients can challenge balance skills by stretching the Achilles tendon and rising to demi-pointe position (ie, on the metatarsal pads) without holding on to a vertical pole. Tendon stretch quickly reveals weaknesses in alignment and muscle patterning.

Figure 12. Toe Spacer
This is a challenging but useful tool for disciplined clients who are willing to work in small increments of progress. The toe spacer, or toe spreader, exercise can initially be done seated, in a non-weight-bearing position, which activates the awareness of midline muscles and, alternatingly, adductor leg muscles.

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The Role of Exercise Therapies for the Management of Posterior Tibial Tendon Dysfunction

Clinicians may find the EdUReP theoretical framework provides helpful guidance for exercise prescription and load management for patients with this potentially disabling condition.

By Talysha Reeve, B.App.Sc.(Podiatry), GradCertClinRehab

Despite the substantial gains in knowledge and understanding of lower extremity tendinopathies in recent years, achieving successful treatment outcomes for those suffering posterior tibial tendon dysfunction (PTTD) often remains a challenge for many therapists. A number of histological and mechanical factors unique to the tibialis posterior (TP) tendon exist and an improved understanding of these factors may improve the management strategies we as practitioners implement for our clients.

The literature regarding inclusion of exercise-based therapies in the management of individuals with lower extremity tendinopathies is growing at a rapid pace. For many clients with PTTD the provision of orthomechanical devices and/or passive therapies alone is not sufficient to successfully manage their condition. In this article we will explore how the inclusion of exercise-based therapies can improve pain and function in those with Stages I and II PTTD.

Posterior tibialis tendon dysfunction is a progressive, often disabling condition and is the most common cause of adult acquired flatfoot deformity (AAFD). PTTD can affect both men and women; however, it is most common in women and the incidence increases with age, with an estimated prevalence of between 3.3% and 10%. Women over age 40 are considered to be at the highest risk of developing this condition.[1,2,3]

A number of inherent problems exist when it comes to the treatment of PTTD. First, it is reported that PTTD is often misdiagnosed by health care practitioners or remains undiagnosed for several years, during which time a patient may progress through a number of stages of the pathology. Tendonitis, ankle sprains, and arthritis are some of the most common misdiagnoses given to this condition. Second, should a correct diagnosis be made in due course, inadequate or incorrect treatment interventions may be implemented due to a failure to understand the complex structural and functional components unique to this pathology in terms of both etiology and treatment.[1,4] Late diagnosis and/or inadequate intervention can significantly limit the efficacy of conservative management and increase the likelihood of requiring surgical intervention.[1,4]

Functional Anatomy, Physiology, and Pathomechanics

To understand how we are to improve our management of the pathology in relation to both mechanical intervention and exercise therapies, we first have to understand the structure and function of the muscle-tendon unit in both its healthy and pathological states.

The tibialis posterior originates from the posteromedial surface of the fibula, posterolateral surface of the tibia, and the interosseous membrane. The muscle-tendon junction is located within the distal third of the calf; the 12-15cm long tendon then flattens and courses behind the medial malleolus to a number of insertions located within the foot. Its most superficial insertions are located on the tuberosity of the navicular and the medial cuneiform. The deeper insertions are located on the plantar aspects of metatarsals 2-4 and the intermediate cuneiform. [5]

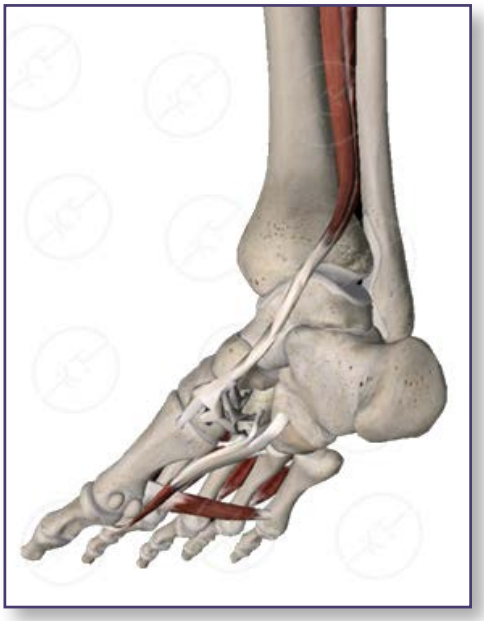

Figure 1. The tibialis posterior tendon.

The TP tendon is considered a gliding tendon and variations exist both biomechanically and histologically from traction tendons (eg, Achilles tendon). Unlike traction tendons, gliding tendons change course and are not in line with their associated muscle fibres. When movement of a gliding tendon occurs, high levels of compressive force exist at the interface with the osseous gliding area. For the TP tendon to withstand these loading forces, 2 structural variations exist: the tendon flattens in the retromalleolar region and it contains high level of fibrocartilage. Previously thought to be pathological, this relatively hypovascular region of fibrocartilage is now considered a normal physiological and protective component of the TP tendon.[5-9]

As we move superficially away from the gliding area, compressive forces decrease and we observe an increase in tensile forces, with the highest level of tensile force existing at the most superficial aspect of the tendon. It

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Table 1. Causes & Risks of Posterior Tibial Tendon Dysfunction

Inflammatory	Rheumatoid Arthritis	Other inflammatory diseases
Mechanical	Tendinopathy impairment Functional impairment Talocrural joint abnormality	Soft tissue tension/traction Pre-existing flatfoot Excessive functional pronation
Metabolic	↑ Cholesterol	Menopause
Others	Infection	Ageing process
Non-Specific Causes	Pregnancy	Micro or macrovascular impairment
Non-Specific Factors that ↑ Risk	↑ BMI Smoking Localized steroid exposure	Long-term medication use Diabetes Hypertension Previous rearfoot trauma/surgery

is within the tensile and compressive force transition zone that we see the highest presence of shear stress. Compressive and shear forces have been identified as a potential contributor to degenerative tendon pathology. Despite their low level of vascularization comparative to other connective tissues, tendon vascular supply is considered sufficient to meet metabolic demands in tendon tissue free from pathology. However, due to the combination of potentially increased pathological stress and high concentrations of hypovascular fibrocartilage in this region, we may see a tendon that develops degenerative tendinopathy due to inadequate healing time before damaging forces are reapplied.[5-9]

Load is a key element in the development of tendon pathology and is further influenced by a range of both intrinsic and extrinsic factors such as age, genetics, body composition, biomechanics, and training characteristics.[10,11] Table 1 summarizes the identified causative and risk factors for developing PTTD.

Unlike a number of other lower extremity tendon pathologies TP load is closely linked with the biomechanical function of the foot. Subtalar joint (STJ) axis, low arch height ratio, and increased foot mobility have been identified as factors that may lead to the development of TP tendon pathology.[12,13]

Tibialis posterior energetics are heavily influenced by the STJ axis, which has implications for both the development and management of PTTD.

The Role of the Subtalar Joint Axis

The TP has the largest supination moment around the STJ and serves a number of mechanical functions during locomotion including: dissipative or elastic energy absorption, contributes to mediolateral stability of the STJ, actively resists STJ pronation during early stance, and actively supinates the STJ during late stance.[18, 21]

The length of the TP supination moment arm is dependent on the location of the STJ axis (see Figure 2). In a normally located STJ axis, the TP moment arm is approximately 2.0cm on average. Those with a medially deviated STJ axis may have a moment arm <1.0cm. Higher degrees of pronation resulting from a medially deviated axis result in an increase in TP tendon forces, increasing the risk of tendon injury. [12,14-17]

Physiologically normal tendons are composed of 95% of collagen type I with very small amounts of types III, IV, and V collagen. In the presence of tendinopathy, we see alterations in collagen synthesis and tendon remodelling. Gonçalves et al performed a histological study on those suffering PTTD compared to controls.[18] Although the study had a relatively small sample size, those with PTTD displayed significantly higher proportions of collagen type III (53.6%) and V (26.4%) and a decrease of more than 40% in collagen type 1. Unlike collagen types III and V, the primary function of type I collagen is to tolerate tensile loads. This altered collagen organization and composition may expose the TP tendon to further injury due to the decreased capacity to tolerate and adapt to mechanical load.[8,18-20]

The continuum model of tendon pathology first proposed by Cook & Purdam in 2008 describes 3 stages of tendon pathology: reactive tendinopathy, tendon disrepair, and degenerative tendinopathy. A tendon may move up and down this continuum through the addition or removal of load. A reactive tendon has an increased likelihood of the tendon structure returning to normal. Tendons in stages of disrepair or degeneration have a limited ability to remodel and return to a normal tendon structure. However, interventions that address load capacity, function, and pain can potentially deliver a pain-free tendon with an acceptable level of function despite the remaining cellular structure deficits.[10,21]

How a tendon may reach the point of disrepair can be partially understood when we look at Young's elastic modulus (see Figure 3), which describes the stress-strain curve and its relation to tendon loading.

- Stress *(compressive, tensile, and shear)* refers to the loading force acting on the structure, divided by cross-sectional area.
- Strain is the deformation or displacement of the structure as a result of the applied stress.

The stress-strain curve sees 3 primary regions. The elastic region, whereby the struc-

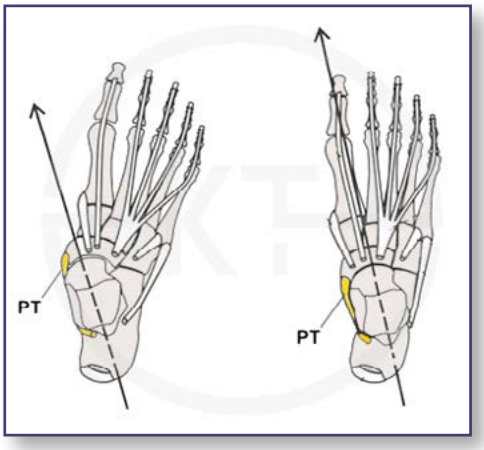

Figure 2. A) Medially deviated subtalar joint axis; B) Normal subtalar joint axis.

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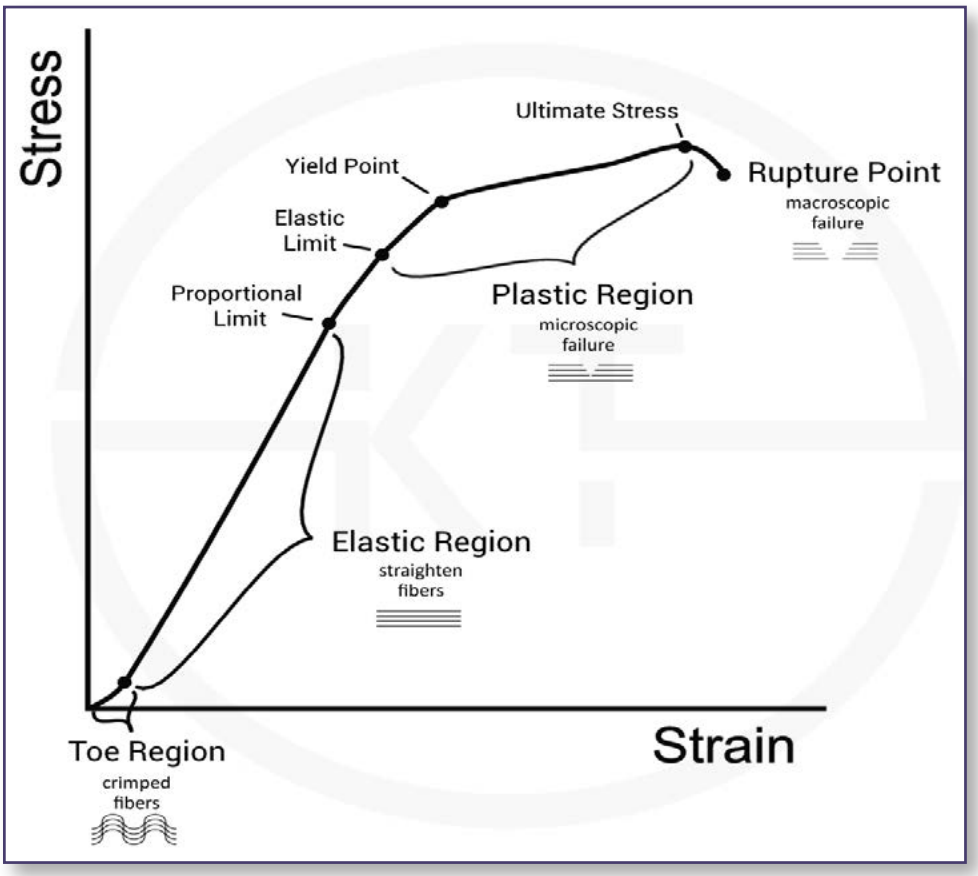

Figure 3. Young's Elastic Modulus.

ture returns back its original shape upon the removal of load. The plastic region is where the structure has reached its elastic limit and we see an increase in strain (load-deformation) relative to stress, increasing risk of partial tearing or rupture. The final region is the rupture point in which we observe a complete failure of the structure.

Injured ligaments and tendons that have reached the plastic deformation region will see an increase in cellular strain on the remaining intact tissue, resulting in an increased risk of further deformation and injury. This is one factor that may explain the accelerated progression of PTTD once plastic deformation of the tendon and associated ligamentous structures has occurred. [8,22-24]

A steep slope in relation to stress-strain indicates a higher degree of tissue stiffness and will undergo a lower rate of load-deformation. Inversely, a shallow slope indicates a higher level of compliance and will experience a higher rate of load-deformation. In regard to the tibialis posterior tendon, a more compliant tendon will absorb more energy allowing for greater pronation in comparison to a stiffer tendon and may result in progressive damage to the tendon structure over time.[13,22]

The TP tendon's function and pathology are influenced by a complex interrelationship of factors, some of which are unique to this structure alone. Table 2 provides a summary of the structural and mechanical factors that often require attention for the successful conservative management of PTTD.

Conservative Treatment Interventions

Conservative mangement is recommended for those in Stages I and II of PTTD. Often those who have progressed in to Stages III and IV require surgical intervention in addition to orthomechanical and physical therapy to address the numerous structural and functional deficits present.

Davenport et al recommends the EdUReP (Education, Unloading, Reloading, Prevention) theoretical framework for the clinical management of individuals with tendinopathies.[25]

Education

Client expectations, their treatment compliance, and the engagement of positive behavioral changes are all built upon a foundation of education and understanding. All of these factors are critically important for achieving successful treatment outcomes with those suffering PTTD. It is recommended that a client has a thorough understanding of: the etiology, pathophysiology, and individual biomechanical factors associated with their condition; importance of load management; importance of treatment compliance; and implications of non-adherence.[4,26]

Unloading

The goal of unloading is to preserve the structural integrity of the affected structures, allow for adequate healing, and prevent further progression of PTTD. This can be achieved via a

Table 2. Structural and Mechanical Factors to Consider for Successful Conservative Management of Posterior Tibialis

Factors	Implications
Hypovascular fibrocartilage	Delayed healing
STJ axis, low arch height ratio, and increased foot mobility	Requires mechanical intervention
Altered collagen composition	Modifiable with load management interventions and exercise therapies
Tendon compliance	Modifiable with load compliance
Microscopic damage/Plastic deformation	Potentially modifiable with load management interventions and exercises
Tendon rupture	Orthomechanical intervention and/or surgery

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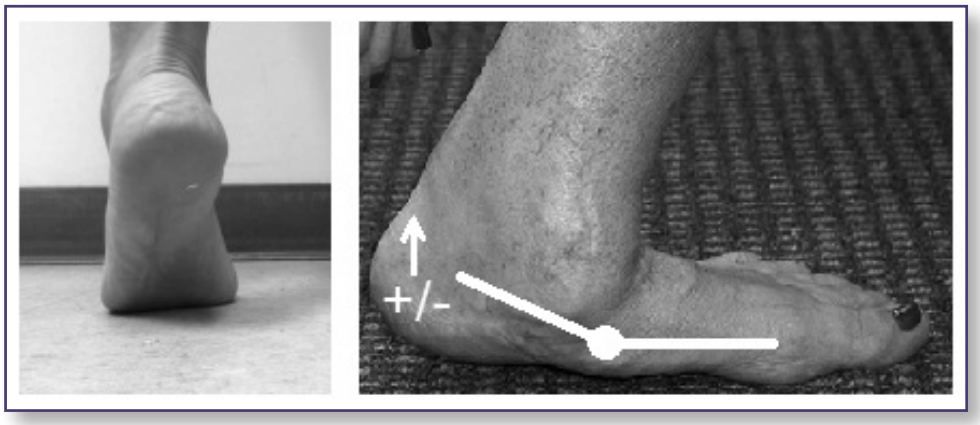
number of methods depending on the individual's needs, including activity limitation, use of foot orthoses (FO)/ankle foot orthoses (AFO), heel lifts, and footwear changes/modifications.

Rest can be as simple as reducing aggravating activities, such as running, through to short-term immobilization when active tenosynovitis or partial tendon tears are present. Periods of immobilization required range from 2-12 weeks depending on the clinical presentation.[27]

Foot orthoses are considered appropriate when the plantar ligamentous structures – and therefore the foot-leg coupling mechanics – are intact. When we clinically observe a disruption in the coupling mechanics between the foot and the leg, the prescription of an AFO device (eg, Ritchie Brace) over a functional FO is recommended.

When combined with a thorough subjective history and objective assessment, the single leg heel raise (SLHR) test is an effective functional test that may assist clinicians in selecting the most appropriate orthomechanical device and serve as a starting point for exercise therapy interventions. Depending on the stage of PTTD, clinicians will observe a number of movement variations when the patient is performing this test with or without the presence of pain.



Normal SLHR (L) **Decoupling & inability to perform SLHR (R)**

Figure 4. A) Normal SLHR; B) Decoupling of foot and leg with inability to perform SLHR.

In the early stages, a client will be able to perform the SLHR, and we will observe a diminished or the absence of calcaneal inversion, indicating TP insufficiency (see Figure 4). As the pathology progresses a decrease in heel raise height will occur, further progressing to decoupling of the foot-leg and eventual inability to perform the SLHR.

When the plantar ligamentous structures are intact, we will observe the relative main-

tenance of the medial longitudinal arch and plantarflexion of the entire foot. In those with disrupted plantar ligaments we observe the rearfoot plantarflex relative to the forefoot.[5,28]

The use of FO or AFO can be enhanced by selecting the appropriate footwear. Motion-control shoes that include medial posting, reinforced heel cups, and a stiff shank are generally considered appropriate footwear for those with PTTD. When managing more athletic clients, cross-training shoes may be beneficial over other sports shoes due to the improved hindfoot control.[30]

Should standard retail shoes be insufficient, orthopedic footwear allows for a high degree of customization and additional areas of support, including: medial flares, medial posting, extended Thomas heel, navicular supports, and reinforcement of the medial heel counter.[27]

Reloading

The evidence supporting exercise therapies for tendon pathologies has risen significantly in recent years with a small number of studies relating to PTTD specifically. We know that various exercises can facilitate collagen repair and increase tendon stiffness or compliance. Exercise selection should be based on the individual's presentation, their individual goals, and the desired physiological response. As with the management of all tendinopathies, there will be significant variation regarding exercise selection, therapeutic dosage, and the treatment response among clients.

For a tendon to positively adapt, we are required to load the tendon within its anabolic range. Too much or too little load and we may further increase the catabolic changes occurring within the tendon structure.[23] Further to tendon loading, the repeated long-term exposure time to load has a profound impact on collagen synthesis. It is theorized that the initial stages of training increases collagen type I turnover to allow for reorganization of the tissue. When the tissue is exposed to more prolonged, repeated bouts of training greater than 4 weeks, we begin to see changes in the strength and cross-sectional area of the tendon structure.[29] The 2008 systematic review conducted by Ross et al found small-to-moderate improvements across outcome measures at 6 weeks.[3] However, a greater number of outcome measures achieved significant improvements when reviewed again at 12 weeks. Previously, Alvarez et al had reported 89% of participants achieved significant improvements in pain and function after participating in the daily exercise loading program after 4 months.[31] Understanding and communicating to your client that the rehabilitation of tendons can take months is important when devising and implementing your treatment plan.

Exercise Therapies for Conservative Management

Despite the small number of studies in relation to exercise therapies for the conservative management of PTTD, we are able to see that those who participate in exercise-based therapies

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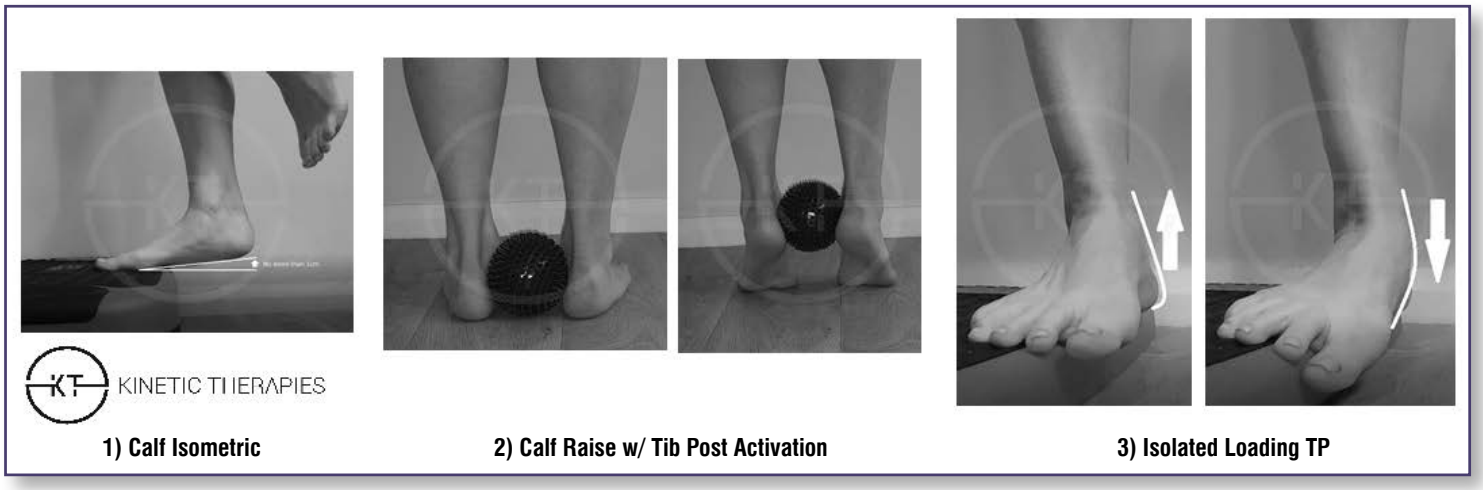

Figure 5. Exercises for managing posterior tibialis tendon dysfunction: A) Calf isometric; B) Calf raise with tibialis posterior activation; C) Isolated loading tibialis posterior.

improve across a range of outcome measures. Overall, eccentric exercises appear to create the biggest improvements across the range of outcome measures, however concentric exercises and stretching exercises all appear to have a positive impact when compared to no exercise intervention at all.

The confounding factor for many clinicians is the selection and dosage of exercises as there are no established protocols. Due to the unique presentation of each client, exercise selection and the overall management plan should be based upon their individual needs and the results of their individual assessment.

Strength and functional deficits have been identified in the gastroc-soleus complex, tibialis posterior, tibialis anterior, peroneals, gluteals, and lateral hip stabilizers in those individuals with PTTD. Targeted strengthening of these muscles in addition to functional strengthening, balance, and proprioceptive exercises have been shown to have positive impacts on pain and function for the management of PTTD.[3,4,26,27,31,32]

As discussed previously, in order for positive adaptation to occur we must load the target structure within its anabolic range. Limiting exercises to non-weight bearing or to low-load resistance band exercises may leave the client 'under-dosed'. As the foot is subject to loads up to 1.5 x body weight during walking, exercise dosing must aim to progressively restore the structures to a point where they are able to tolerate the required loading demands.[23] To facilitate an increased activation of the TP, have a client perform their rehabilitation exercises wearing their prescribed foot orthoses; use of supportive shoes may assist.[26]

A range of both bilateral and unilateral weight-bearing exercises can be incorporated into the rehabilitation of PTTD. Figure 5 provides examples of exercises that may benefit an individual with this condition.

As ankle equinus resulting from shortening of the Achilles tendon is a common finding in those with PTTD, stretches that aim to improve ankle dorsiflexion range of motion (ROM) are routinely prescribed. The inclusion of gastrocnemius and soleus stretching exercises that place the ankle in maximal dorsiflexion ROM may be counterproductive to the treatment goals in some cases. Understanding that the PT tendon experiences high degrees of compressive load as it courses behind the medial malleolus, the prescription of maximal range calf stretches may flare symptoms and/or lead to further damage of the tendon by the additional compressive loading. The addition of calf stretches may be included once acute symptoms have subsided.[3,27]

In summary, we can identify a number of factors that highlight the need for the combination of load management and exercise-based therapies for the successful management of Stage I and II PTTD. As tendon structures require repetitive exposure to high loads within their anabolic threshold in order to positively adapt, the application of orthomechanical devices and/or passive therapies alone will unlikely be sufficient to significantly improve pain and function in those individuals with PTTD.

Exercise rehabilitation plans should be devised based upon individual assessment, client treatment goals, and functional requirements. It is important for clinicians and their clients to understand that the conservative management of PTTD can take months and requires a high level of adherence to treatment interventions to achieve a successful outcome. However, should an individual adhere to their management plan, the chance of successful pain reduction and functional improvement is high. ler

Talysha Reeve, B.App.Sc.(Podiatry), GradCert-ClinRehab, is a podiatrist and former private clinic owner in Adelaide, South Australia. She has a special interest in the management of complex biomechanical and musculoskeletal conditions, with particular focus on their treatment via movement-based therapies and load management. Currently she divides her time between private clinical practice and delivering continuing professional development courses via Kinetic Therapies.

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Preventing Re-ulceration in Diabetes

In a recent short review, Michael J. Mueller, PT, PhD, FAPTA, provided 5 evidence-based suggestions for helping patients with diabetes and peripheral neuropathy (PN) safely and effectively increase their mobility after a healed foot ulcer. Mueller is a professor of physical therapy and radiology at Washington University School of Medicine in St. Louis.

In general, patients with healed foot ulcers also have multiple medical co-morbidities, including complications from diabetes that affect the cardiovascular system, the kidneys, the eyes, and most significantly, the peripheral nerves. In addition, the rate of re-ulceration is quite high for this population, from 40% at 1 year, to 60% at 3 years, and 65% at 5 years.

Adding to the health challenges, this group averages only 2000 steps per day (compared to those with diabetes, PN, and no ulcer at twice as many steps, and healthy controls at 4-5 times as many). While there is an association between high plantar pressures and neuropathic plantar skin breakdown, many experts believe that the skin tissues become less tolerant to everyday physical stresses due to disease progression combined with the reduction in weight-bearing activities after initial ulceration.

Newer evidence is showing that structured interventions can lead to high step counts and improved foot outcomes in patients with diabetes and PN. This newer evidence has led to changes in guidelines from both the American Diabetes Association and the International Working Group on the Diabetic Foot. The challenge that Mueller sought to answer in his review: how to safely resume and even enhance activity in this set of patients, considering existing foot deterioration (which allowed the ulcer to develop in the first place), prolonged immobilization and inactivity and the subsequent further deterioration and stress intolerance of the foot?

His overriding principle: progress slowly and consistently over the first 3 months after off-loading. Here's the 5 steps he identified.

1. Because most ulcers recur in the first 3 months after healing, and particularly in the first month, carefully limit the initiation of activity while continuing moderate-to-maximum off-loading. The sharp increase in activity, he writes, is a likely contributor to early re-ulceration. Citing Brand's emphasis on continued protection during healing, Mueller notes that the connective tissues around the wound continue to mature for weeks and months after the wound's initial closure. He suggests weaning patients from off-loading devices for 1-2 hours per day, with that time spent in therapeutic footwear; this allows the foot to tolerate small amounts of plantar pressure for a limited time each day. Then, over the course of 20-30 days, slowly increase the amount of time each day spent in the therapeutic shoes until the patient can tolerate a full day's wear. Both feet should be examined daily for any signs of redness or unusual skin issues.
2. Patients should transfer from the off-loading device into therapeutic footwear. These shoes should fit properly, accommodate the unique shape of the patient's foot, and provide relief from plantar pressures. In accordance with Brand's recommendation for a "healing shoe" – a shoe that can be worn specifically during this time, and mainly at home for recovery, Mueller notes that a second pair of shoes is also listed in newer guidances.
3. Citing prior work, Mueller recommends increasing average daily step count by approximately 10% every 2 weeks. This works in line with the idea of gradually weaning from the off-loading device while still maintaining daily visual inspections of the feet. He notes this may not be possible in patients with a severe deformity and recommends they be encouraged to meet activity goals by riding a stationary bicycle or swimming with protective pool shoes.
4. Research shows that the tissue in newly healed wounds has a limited capacity for stress tolerance, meaning sudden changes in cumulative stress can lead to skin failure. As such, Mueller advises that patients should avoid large daily variations in weight-bearing activities. He suggests that wheelchairs or scooters might be considered for one-day excursions that can't be postponed until the transition phase is over. Additionally, referrals for physical therapy to improving strength, joint mobility, and overall activity might be considered.
5. Previous research has shown that pre-ulcerative lesions can be stopped from developing into ulcers once patients and their caregivers know what to look for. Advising patients on how to visually inspect their feet every day is key to this type of prevention. Daily inspection allows patients to identify skin changes, redness, or inflammation before they become significant problems.

Source: Mueller MJ. Mobility advice to help prevent re-ulceration in diabetes. Diabetes Metab Res Rev. 2020;36(S1):e3259.

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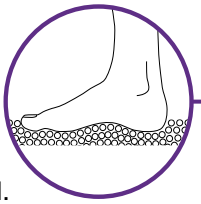

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New & Noteworthy

Noteworthy products, association news, and market updates

AMPHIBIOUS PROSTHETIC LIMB

In an effort to restore aquatic mobility and independence to lower limb amputees, a team of researchers and doctors at the Feinstein Institutes for Medical Research at Northwell Health, Manhasset, NY, developed a state-of-the-art, 3D-printed amphibious prosthetic limb known as The Fin. Printed at a lower cost than traditional swim prostheses, The Fin features conically shaped holes in the pylon, which control the amount of water flow to create a natural amount of drag and propulsion. A non-slip sole and an ergonomic shape ensure safe, durable, and efficient movement on land and in water. The Fin allows amputees to easily transition between swimming and walking on land without changing their prosthesis.

Northwell Health
northwell.edu/research-and-innovation/the-fin

INTELLISENSE TEMPERATURE-REGULATING CUSTOM ORTHOTICS

Foot Levelers has introduced IntelliSense custom orthotics. These smart insoles add comfort while the phase-change top cover helps keep feet regulated in a temperature-controlled comfort zone through the changing seasons. This means feet are kept warm in the winter and cool in the summer. The orthotics also incorporate a Dryz top layer to wick perspiration away from the feet, which helps to control odors by killing harmful fungi and bacteria. IntelliSense custom orthotics feature the company's patented 3-arch support. By stabilizing the feet, Foot Levelers custom orthotics are designed to help level the pelvis and reduce pain throughout the body.

Foot Levelers
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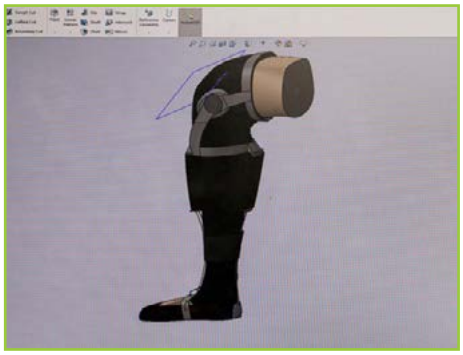
UD TEAM RECEIVES FUNDING TO FURTHER DEVELOP SMART AFO FOR CHILDREN WITH CP

The Venture Development Center and Physical Therapy Department at the University of Delaware (UD) have received $50,000 in seed money from the Pennsylvania Pediatric Medical Device Consortium to further develop a motorized ankle-foot orthosis (AFO) called the DE-AFO. The DE-AFO, designed by Ahad Behboodi, PhD, and his team, uses electro-active polymer as artificial muscles to assist ankle motion in children with cerebral palsy (CP). The soft muscle-like smart material contracts in response to electric current. The team also received a $200,000 grant last year from University City Science Center, Philadelphia, PA, to work on the device.

Made from off-the-shelf elastic materials, these artificial muscles closely mimic the function of the body's skeletal muscle and can help children with CP who struggle to complete a range of motion (ROM) under their own power. The device is lightweight, compact, comfortable, and noiseless, reducing the size of the orthosis needed while increasing the wearer's degree of freedom in movement. Computer software operates the artificial muscle.



The researchers said the proposed AFO is the first lower extremity device designed to correct alignment or provide support using soft muscle-like smart materials that contract in response to electric current. Image courtesy of UD.

Traditional AFOs keep the ankle and foot stable but don't allow for movement, which can cause muscles to weaken and atrophy from disuse. The UD team's device potentially can minimize this atrophy because it will allow muscles to go through an ROM. For example, if a child needs help lifting her toes for her foot to clear the ground as she walks, the device can assist the front calf muscles to lift up the ankle.

The researchers said they can imagine the brace being used as an exercise device, too, where the artificial muscle might resist against the child's movements to strengthen or stretch muscles or increase ROM. Further, in the future they may add functional electrical stimulation technology to also trigger muscles, when needed. This would improve the timing and power of the artificial muscle's activation, thereby strengthening the user's muscles and improving walking coordination.

NEW C-TEK MODSTIFF MATERIAL FOR ORTHOSES

When fabricating orthoses, many clinicians and technicians have sought a material with a flexural modulus (stiffness) between modified polyethylene (MPE) and copolymer polypro-

pylene (copoly), with a 52 kpsi stiffness and 200 kpsi stiffness, respectively. In response, Curbell O&P, a division of Curbell Plastics, has introduced C-TEK MODStiff, based on polyethylene with a stiffness of 109 kpsi. The material can be used in applications such as night splints, AFOs, TLSOs, and SMOs, where MPE is not stiff enough and copoly is too stiff. The ability to down gauge material thickness provides the opportunity to lighten the weight of an orthosis. C-TEK MODStiff sheet is easy to fabricate with and form; no special fabrication techniques or equipment are needed. The material will "clear" in the oven similar to MPE and copoly. It is available in 2 thicknesses, 0.125" and 0.156", and 2 sheet sizes, 24" x 48" and 48" x 96".

Curbell O&P
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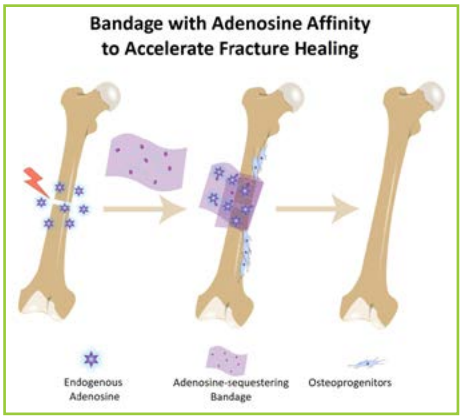
DUKE RESEARCHERS ENGINEER BONE BANDAGE TO ACCELERATE HEALING

Researchers at Duke University (Duke) have engineered a bandage that captures and holds a pro-healing molecule at the site of a bone break to accelerate and improve healing. In a proof-of-principle study with mice, the bandage helped to accelerate callus formation and vascularization to achieve better bone repair by 3 weeks. The research points toward a general method for improving bone repair that could be applied to biodegradable bandages, implant coatings, or bone grafts. The results were published earlier this year in *Advanced Materials*.

In 2014, Shyni Varghese, PhD, professor of biomedical engineering, mechanical engineering and materials science, and orthopedics at Duke, discovered that the biomolecule adenosine plays a large role in spurring bone growth. After further study, researchers in her laboratory found that the body naturally floods the area around a new bone injury with adenosine molecules, but those locally high levels are quickly metabolized and don't last long. Varghese wondered if maintaining those high levels for longer would help the healing process.



A new type of bone bandage traps naturally produced adenosine close to the break, which promotes and accelerates healing at the site before slowly releasing the adenosine back into the body. Image courtesy of Duke.

However, "adenosine is ubiquitous throughout the body in low levels and performs many important functions that have nothing to do with bone healing," Varghese said. Her solution to avoid unwanted side effects was to let the body dictate the levels of adenosine while helping the biochemical stick around the injury a bit longer. She and Yuze Zeng, a graduate student in her laboratory, designed a biomaterial bandage applied directly to the broken bone that contains boronate molecules, which grab onto the adenosine. The bonds between the molecules do not last forever, which allows a slow release of adenosine from the bandage without accumulating elsewhere in the body.

In the current study, Varghese and her colleagues first demonstrated that porous biomaterials incorporated with boronates could capture the local surge of adenosine following an injury. They then applied bandages primed to capture the host's own adenosine or bandages preloaded with adenosine to tibia fractures in mice. After more than a week, the mice treated with both types of bandages were healing faster than those with bandages not primed to capture adenosine. After 3 weeks, while all mice in the study showed healing, those treated with either kind of adenosine-laced bandage showed better bone formation, higher bone volume, and better vascularization.

The results showed that not only do the adenosine-trapping bandages promote healing, they work whether they're trapping native adenosine or are artificially loaded with it, which has important implications in treating bone fractures associated with aging and osteoporosis.

"Our previous work has shown that patients with osteoporosis don't produce adenosine when their bones break," Yuze said. "These early results indicate that these bandages could help deliver the needed adenosine to repair their injuries while avoiding potential side effects."

CONFORMIS APPOINTS NEW CFO AND SVP, OPERATIONS

Conformis, Billerica, MA, a medical technology company that uses its proprietary iFit Image-to-Implant technology platform to develop, manufacture, and sell patient-specific knee and hip joint replacement implants, announced the appointment of Bob Howe as chief financial officer, and Gary Maingot as Senior Vice President, Operations.

Howe is a senior finance professional with over 20 years of progressive experience at public medical device companies in roles that encompass financial planning and analysis (FP&A), financial reporting, and business strategy. He has an MBA from Boston University and a Bachelor of Science in finance and entrepreneurial studies from Babson College.

Maingot is a senior executive with over 25 years of progressive experience within the medical device industry and has a track record of solving complex problems in the interdependent functions of quality, engineering, operations, and supply chain. He earned an MBA degree at Babson College, a Master of Science in industrial engineering at the University of South Florida, and a Bachelor of Science in statistics at the University of Western Ontario.

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NeoRelief for Muscle Cramping and Restlessness is a 97%-natural pain relief gel that is formulated to relieve muscle spasms, cramping, tingling, and symptoms associated with restlessness. This patent-pending blend of botanicals and minerals is clear, non-staining, and odorless. It is easily absorbed and free from alcohol, dyes, and perfumes. The active ingredients include arnica, causticum, Rhamnus californica, ruta, and taraxacum for muscle calming; belladonna, cimicifuga, gnaphalium, Hypericum perforatum, jatropha, and veratrum for relief of muscle spasms and cramps; and cina, ignatia, Kali brom, Kali carbonicum, lycopodium, scutellaria, and Valeriana officinals for relief of muscle twitching and jerking. All active ingredients are in the official Homœopathic Pharmacopœia of the United States (HPUS), and follow homeopathic standards of strength, quality, purity, and packaging. A 90-day money-back guarantee is offered.

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FOOT SOLUTIONS ACQUIRED BY PRIVATE INVESTOR GROUP

Foot Solutions, Atlanta, GA, announced the acquisition of the business by a group of private investors. John Prothro, an experienced executive and one of the anchor investors, has been appointed CEO and will be leading the company day-to-day. The previous owner and CEO, Ray Margiano, PhD, will be a special advisor to the company leadership. Prothro and his investors plan to invest in a series of growth initiatives designed to build the company and improve operations, starting with a renewed focus on marketing and customer education.

FITTRACK DARA SMART SCALE

The FitTrack Dara Smart Scale offers insight into the user's day-to-day and long-term health. Using Advanced Dual BIA [Bioelectric Impedance Analysis] Technology, FitTrack provides a complete body composition analysis that syncs to the free connected FitTrack Health App. The user can measure, track, and trend progress of 17 different health metrics, such as body water, bone mass, muscle mass, muscle rate, metabolic age, and more. Personalized insights are received through the customizable dashboard in-app. This allows the user to see progress being made beyond weight loss, with the intention of helping users stay motivated in their health journey via an understanding of these metrics.

FitTrack
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COMB O&P LAUNCHES IPHONE SCANNING APP FOR O&P PROFESSIONALS

Comb O&P, Cleveland, OH, an orthotic and prosthetic (O&P) shape capture company, has announced that its Comb 3D Scanner App is now available on the iPhone App Store. The state-of-the-art app leverages the iPhone's TrueDepth camera, powered by KNOCKOUT 3D™, to capture 3D scans of body parts—no additional attachments or hardware is needed. According to Comb O&P, the app was launched to fill an unmet need for the market of molding/capturing parts of the body for fitting custom-made bracing and orthopedic appliances. The app offers practitioners an accurate, low-cost, and portable tool to capture 3D scans of legs, feet, knees, arms, and the torso. Practitioners can quickly review and upload saved scans as .obj or .stl to the Health Insurance Portability and Accountability Act–compliant Comb portal. To prepare for rectification and fabrication, scans can be downloaded and imported into popular CAD/CAM software.

Comb O&P
combscan.com

RUNGOO PROTECTIVE FOOT CREAM

Active feet sweat and swell, and even the best footwear does not fit everyone perfectly under all conditions. RunGoo is a barrier cream, formulated to prevent blisters in the harsh environment of a boot or shoe. By forming a protective layer on the skin's surface, RunGoo protects feet from the friction and heat that cause blisters and soft tissue bruising. A combination of hard and soft waxes provides a durable protective barrier that absorbs slowly over the course of the run, hike, or walking activity. A single application lasts all day. By the end of the day, feet are moisturized and fresh, and socks wash clean.

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REMINGTON PRODUCTS ACQUIRES FOOT PETALS

Remington Products, Wadsworth, OH, manufacturer of aftermarket insoles and orthopedic soft goods, has acquired the Foot Petals brand of foot cushions and inserts from RG Barry Corporation, Pickerington, OH. The acquisition will allow the companies to merge their complementary strengths and collective resources.

STS COMPANY RIGID DRESSING SOCK

The Rigid Dressing Sock from STS has been designed for use as a component in a post-operative rigid dressing for a residual limb after amputation. This lightweight sock helps protect the limb, while its uniform compression assists in controlling surgical edema. It is made from polyester and Lycra and impregnated with a water-curable polyurethane resin. The rigid dressing sock unrolls quickly and easily, and the rounded, closed end allows for easy application—virtually eliminating all wrinkling while providing excellent conformity. In only 5 minutes after cure time, 90% of strength is achieved. The Rigid Dressing Sock is available in 3 widths.

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X4 FOOT & GAIT MEASUREMENT SYSTEM

Xsensor's X4 Foot & Gait Measurement System provides accurate, easy-to-use gait, foot function, and plantar pressure data for any patient evaluation scenario, including surgical or therapeutic interventions and pathology. It is also useful in

providing real-time feedback for patients with diabetic foot ulcers and is part of an effective treatment plan. The compact and discreet on-shoe wireless electronics are paired with durable, thin, and flexible insole sensors. Proprietary capacitive sensor technology combined with high-speed sampling means users can collect anatomically accurate in-shoe data from 230 sensels. The accompanying software enables clinicians and therapists to review high-accuracy, high-resolution dynamic pressure data and imagery to see a patient's pressure points in real time and be able to adjust their footcare plan as required. With the easy-to-use file manager, users can display and compare multiple recordings side-by-side, complete with summary statistics and measurements, and generate reports.

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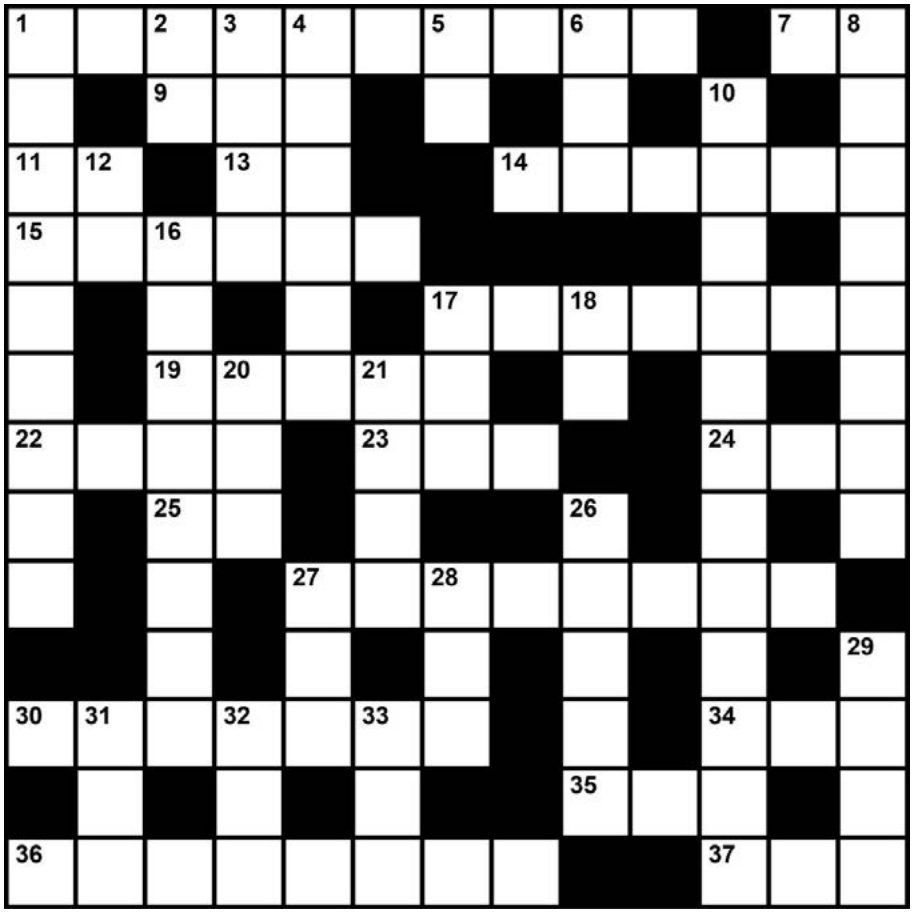

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1 Josephus Pilates' original name for Pilates
7 Start!
9 Mineral deposit
11 Light metal symbol
13 For example, abbr.
14 Position for most exercises when using the Reformer
15 Extend
17 Components of Pilates machines
19 Wispier, like lanugo
22 Reduce the temperature
23 Innovative
24 _____ spacer, inventive part of the Pilates repertoire
25 Memo start
27 Pilates corrects poor _____
30 Accord (Pilates was designed to create this, between body and mind)
34 Wedding words
35 Lightweight versatile step barrel in Pilates
36 Initial series of exercises on the Reformer
37 Watch

DOWN

1 Pilates that adheres most closely to the original method
2 Dentist's laughing gas, abbrev.
3 Decision _____, step-by-step guide to diagnosis or treatment
4 Recover
5 Dieter's unit of measure, abbr.
6 African antelope
8 Supervises
10 Awareness of body motions, a key element in Pilates
12 Old vinyl record
16 Developed by Pilates to help his WWI platoon members recover from injury
17 ____historic
18 ____ and behold
20 French for island
21 _____scope, for GI investigations
26 a/k/a the Pilates "Magic Chair"
27 Expert
28 Versatile dietary bean protein
29 a/k/a "powerhouse" in Pilates
31 _____lipoprotein A or B
32 Some Pilates exercises can be performed on this
33 Lieut.'s subordinate

CROSSWORD BY MYLES MELLOR

With over 12,000 crosswords published internationally, Myles Mellor is one of the top crossword writers in the world. His work includes crosswords, diamond crosswords, syndicated puzzles, cryptograms, diagramless crosswords, word search, sudokus, anagrams, and word games published on mobile devices and e-readers. www.themecrosswords.com