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contents

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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.

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

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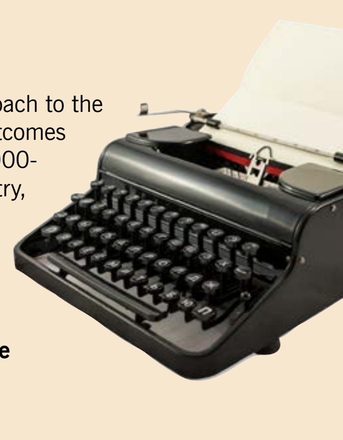

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What If the Ankle Is More Than a Class 2 Lever?

By Thomas J. Cutler, CPO, FAAOP

A knowledge of the historic and philosophical background gives that kind of independence from prejudices of his generation from which most scientists are suffering. This independence created by philosophical insight is—in my opinion—the mark of distinction between a mere artisan or specialist and a real seeker after truth.

Albert Einstein, Letter to Robert Thornton, 1944

The realm of orthotics and prosthetics (O&P) is based on gaining leverage for patients and eking out power when strength is not plentiful. A physical therapist will work with a patient over time to gain power through strengthening exercises where the surgeon may be focused on securing a torn ligament or fracture in hours. But the toolbox of the orthotist-prosthetist is an array of resources designed to optimize the dark side of biomechanics: Reactive Biomechanics—those passive forces that take energy, create leverage, and return more power in an instant. For the orthotist-prosthetist, **biomechanics is currently all about levers and leverage.**

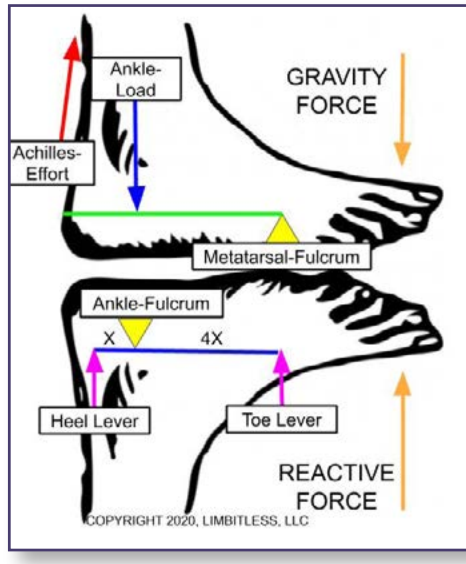
But there appears to be a multidisciplinary disconnect around the biomechanics of the ankle that is becoming increasingly burdensome as we see the rise of post-traumatic arthritis of the ankle (PTAA), most likely caused by sprains or other trauma incurred 10 or more years earlier.[1,2] As this societal burden continues to rise and our ability to "fix" it remains limited, perhaps it's time to consider the words of physicist Dr. Carlo Rovelli, director of the Quantum Gravity Group at Aix-Marseille University, who said "...before experiments, measurements, mathematics, and rigorous deductions, science is above all about vision. Science begins with a vision. Scientific thought is fed by the capacity to 'see' things differently than they have previously been seen."[3]

Historically, the mechanical advantage of the human ankle has been understood in medical and research communities to be a class 2 lever.[4] And this can be explained by a commonly-overlooked premise of osteokinematics that requires the observer to describe movement in anatomical position. In short, we've been asked to discuss joints from only one perspective.[5] But just as the ankle can move in many directions, is it possible to gain insights by recognizing ankle forces from both active and reactive perspectives?[6] Indeed, when Zelik et al reanalyzed previously published data, they found "…>30% of the energy changes during the push-off phase of walking were not explained by conventional joint- and segment-level work estimates, exposing a gap in our fundamental understanding of work production during gait."[7]

So, in addition to the classic textbook presentation of a class 2 lever, couldn't the ankle also be understood in the reactive direction to gravity as a class 1 lever? Otherwise, shouldn't it be explicitly stated that Newton's third law of motion is "equal and opposite and identical"? But it obviously isn't, despite being represented as such in biomechanics research. Since both the action and the reaction of gravity apply to the ankle at all times, would a modern understanding of the ankle incorporate both lever classes? Perhaps we need to challenge what we thought we knew about the ankle to come up with better, more cost-efficient, patient-friendly solutions.

A Question

To that end, a survey was conducted at the 2017 Annual Meeting of the American Association of Orthopaedic Surgeons and its findings presented at the 2019 Annual Meeting of the American Orthotic & Prosthetic Association.[8] Survey takers were provided with illustrated depictions of the 3 known lever classes and asked which lever class applied to the human ankle. They were



allowed to check any that apply. The explicit provision of all 3 lever classes was intended to provide a full range of biomechanical options. Respondents totaled 50; 58% (n=29) identified as MD/DO; 24% (n=12) identified as affiliated with manufacturers; and 18% (n=9) identified as engineers, researchers, medical students, or teaching faculty.

Results to the survey[8] question were as follows: Overall, 50% selected Class 1, 22% selected Class 2, 26% selected Class 3, and one MD/DO reported "No idea." Of the MD/DO category, 60% selected a Class 1 lever, with 20% each selecting Class 2 and Class 3 levers. Of the manufacturer category, respondents were equally split among the three choices (4 in each lever class). Of the category with the balance of 9 respondents, 4 selected a Class 1 lever, 2 selected a Class 2 lever, and 3 selected a Class 3 lever.

Unexpected Findings

This study was initially conducted with the assumption that if provided with depictions of all 3 lever classes, clinicians would unanimously select the lever class designated as correct from textbooks and the American Society of Biome-

Continued on page 10

Continued from page 9

chanics. That is, if provided with clear depictions of each lever class, subjects would select class 2 levers 100% of the time. It was therefore highly unexpected to have only 22% of respondents select this answer. It was further surprising to note that this response rate fails to reach the 33% rate typical of random chance.

Interestingly, the manufacturers who would not be classified as clinicians with the same biases, had response rates that did reflect random chance.

These results indicate that medical professionals with significant experience develop a heuristic awareness of the reactive biomechanics of the ankle. According to the results, practitioners intuitively understand how it functions reactively as a class 1 lever. In fact, the results indicate that in selecting the reactive configuration at 3 times the rate they selected the active configuration, surgeons with practical experience see the ankle differently from its understanding in academia.

Before proposing an inclusive resolution, it must be noted that a "rocker" as it relates to biomechanics, is jargon because it is a misnomer. Despite having gained wide usage and application, "rocker" was used initially by Dr. Jaqueline Perry in her research as a simile. Thus, she provided a literary tool and not an engineering mechanism. Rather than seeing only a single type of ankle leverage, Divergent Reactive Leverage addresses the simile and incorporates an understanding of both types of leverage at play.

While gravity is naturally the first recognized force in the equation, Reactive Biomechanics requires modeling the reactive (normal) force as a class 1 lever prior to modeling the applied ankle force of the plantarflexors. With the 4-fold increase in moment arm of the reactive toe lever, error rates found in research (Figure)[9] with current ankle modeling are eliminated and a new appreciation of the lower extremity is possible.

Modeling indications for Divergent Reactive Leverage are straightforward, but as of yet, unexplored.

Thomas J. Cutler, CPO, FAAOP, is a prosthetist, biomechanist, innovator, and researcher at Limb.itless, LCC. In Visalia, California. He welcomes questions and comments about Divergent Reactive Leverage and Reactive Biomechanics. He can be reached at cutlercpo@gmail.com.

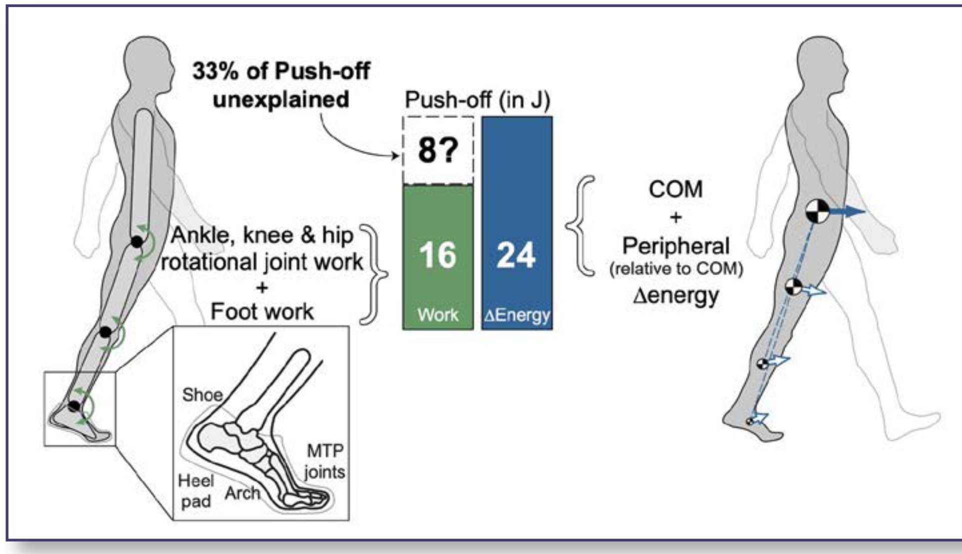


Figure. Unmeasured positive work. Push-off kinetics are not explained by conventional joint- and segment-level biomechanical measures, based on our re-analysis of previously published data (Zelik and Kuo, 2010). At 1.4 m s−1 there is about 24 J of total positive energy change (Δenergy) during Push-off, which reflects the redirection of the body's center-of-mass (COM) velocity, and also the motion of segmental masses relative to the COM (termed Peripheral energy change). We can compare this total energy change estimate with the mechanical work computed from commonly used joint- and segment-level estimates. We observe that the Push-off work performed by the stance limb joints and foot segment – work performed rotationally (represented by green arrows) about the hip, knee and ankle joints [from 3 degree-of-freedom (DOF) inverse dynamics] and work performed by the foot [a combination of metatarsophalangeal (MTP) joint rotations and other deformations within the foot and shoe] – only sums to about 16 J. Thus, these conventional measures fail to account for 8 J (33%) of the Push-off kinetics. Reproduced with permission from Zelik K, Takahashi KZ, Sawicki GS. Six degree-of-freedom analysis of hip, knee, ankle and foot provides updated understanding of biomechanical work during human walking. J Exp Biol. 2015;218(Pt.6): 876-886. Available at https://jeb.biologists.org/content/218/6/876.long

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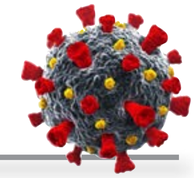

The Impact of The COVID-19 Pandemic on Global Humanitarian Efforts: A Crisis Within a Crisis

By Windy Cole, DPM

The sun is rising as a mass of people gather outside the Landmark Hotel in Amman, Jordan. It is the first day of the Atlantic Humanitarian Relief (AHR) October 2018 Medical Mission. One hundred volunteers from 15 different countries including the United States, United Kingdom, Sweden, Ireland, South Africa, Portugal, Greece, Kuwait, Qatar, Syria, and Jordan have descended upon this capital city as part of an international humanitarian effort to provide medical care to a large population of displaced Sryrian refugees. Alongside me in the crowd are surgeons, pediatricians, internists, primary care physicians, EMTs, psychologists, RNs, PAs, pharmacists, medical students, and humanitarians. We all are issued our daily schedule as we part ways to look for our assigned bus numbers. We are strangers now, but we will soon find out that we are kindred spirits.

The Syrian Civil War has left over 7.4 million people without a home; and more than 5 million have sought refuge in surrounding countries like Lebanon, Turkey, Egypt, and Jordan.[1] Some of these countries have been stretched beyond their limits with resources, thus leaving women, children, and the elderly especially vulnerable. Many Syrians are living on less than the bare minimum. In Jordan, there is an estimated total of 5.5 million refugees, and that number is growing as tensions rise in many parts of the world.[1] Many are struggling to rebuild their lives in these countries.

During this 6-day medical mission, AHR teams will travel throughout Jordan to refugee camps, make-shift medical clinics, school yards, group housing, and private hospitals and will conduct roughly 5,000 patient consultations including 522 dental visits and over 1,000 surgical screenings and procedures. I provide care to patients suffering from traumatic war injuries, pressure wounds, lower extremity amputations, and chronic wounds as a result of uncontrolled diabetes and peripheral vascular disease. While the focus of humanitarian efforts is outward, the benefits are also felt inward. This amazing experience helped me rediscover my purpose and taught me to better listen to patients and consider their economic and social needs when determining care plans.

In recent years there has been increasing interest in global health initiatives. Both the private and public sector have recognized the need to address the disparity in access to healthcare throughout the world. The World Health Organization reports that the highest proportions of the global burden of disease and disability falls on regions that also suffer the most significantly from physician shortages.[2] Although there is no one central monitoring group or agency for medical missions, conservative estimates, not including travel costs incurred by volunteers, tallied annual expenditures over $250 million in 2014 from the United States alone.[3]

In the wake of the COVID-19 pandemic, international travel has become restricted and countries have closed their borders. As an effort to protect the safety and security of volunteers, aid organizations such as AHR have suspended all medical missions. The coronavirus has made it impossible for these organizations to travel in and out of countries that need the most help.

In places like Syria, years of conflict and deliberate targeting of healthcare facilities has significantly weakened the healthcare system. According to a recent report from the International Rescue Committee, only half of the health centers and hospitals in Syria are currently functional, thus leaving only 28 ICU beds and 11 ventilators for a population of nearly 17 million.[4] One-third of the country remains displaced with most living in overcrowded camps. Nearly an additional million more people have been displaced from northwest Syria since December 2019 alone.[4]

Continued on page 14

Continued from page 13

This amazing experience helped me rediscover my purpose and taught me to better listen to patients and consider their economic and social needs when determining care plans.

How are people to wash their hands if they have no soap or running water? How can you maintain social distancing when you live in a camp that is 4-times more densely populated than New York City? The COVID-19 pandemic will exacerbate the economic crisis as humanitarian efforts that provide life-saving medical supplies are hindered.

This pandemic continues to cripple developing countries around the world. The long-term ramifications of the COVID-19 crisis could decimate refugee communities already suffering from malnutrition, poor sanitation, lack of clean water, and basic medical care. History here at home has taught us that those with fewer resources are hit the hardest by pandemics. During the H1N1 outbreak, the US Native American population suffered a mortality rate 4 – 5 times that of the general US population.[5] Evidence also continues to mount during this current coronavirus pandemic that there have been a disproportionate number of COVID-19 infections and deaths within the African American community.[6] War-torn third world countries already suffering under corrupt governments and burdened with large refugee populations will be the hardest hit. This disruption in medical supplies and other resources will continue to impact these areas slowing their recovery. When we consider the fact that pre-pandemic health disparity and humanitarian funding was already barely able to keep up with global demand, the need for reallocation of funding and perhaps a call for a global health response stimulus plan seems eminent.

We have seen the rapid global spread of the coronavirus as a result of the interconnectedness of today's world. Cooperation between both governmental and private organizations will be imperative to rebuild infrastructure in the aftermath of this current healthcare crisis. The burden will fall on the developed world to share best practices, knowledge, experiences, and remaining resources. New innovations in artificial intelligence, telemedicine, and other virtual platforms may allow improvement in care and education in the US and abroad without the need to physically cross borders. In an increasingly globalized world, humanitarian efforts during the COVID-19 pandemic and beyond will remain of utmost importance. I encourage readers to continue to find ways to help underserviced populations both locally and abroad. ler

Windy Cole, DPM, serves as Medical Director of the Wound Care Center, University Hospitals Ahuja Medical Center and Adjunct Professor and Director of Wound Care Research at Kent State University College of Podiatric Medicine, both in Cleveland, Ohio. She is a dedicated healthcare advocate with interests focused on medical education, diabetic foot care, wound care, limb salvage, clinical research and humanitarian efforts. Dr. Cole has published extensively on these topics and is a sought-after speaker both nationally and internationally. Dr. Cole also serves as a member of the Editorial Advisory Board for LER.

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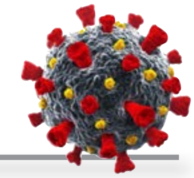

Extrapulmonary manifestations of COVID-19

While the respiratory pathology of COVID-19 has taken center stage over the last 6 months, data is beginning to accrue related to its extrapulmonary manifestations, and they are many and widely variable. Conditions that have been associated include thrombotic complications, myocardial dysfunction and arrhythmia, acute coronary syndromes, acute kidney injury, gastrointestinal symptoms, hepatocellular injury, hyperglycemia and ketosis, neurologic illnesses, ocular symptoms, and dermatologic complications. Studies have shown that SARS-CoV-2 has a higher affinity of binding to the ACE2 receptor than SARS-CoV (responsible for SARS epidemic of 2003), which may explain the increased transmissibility. Because ACE2 is expressed in multiple extrapulmonary tissues, several mechanisms may play a role in the multi-organ injury that is secondary to SARS-CoV-2 infection including direct viral toxicity, endothelial cell damage and thromboinflammation, dysregulation of the immune response, and dysregulation of the renin-angiotensin-aldosterone system. Many of these may also occur secondary to sepsis.

To help clinicians and researchers recognize and monitor the organ-specific pathologies, presentations, and clinical management considerations for patients with COVID-19, a group of more than 25 experts published a review in *Nature Medicine* that is available Open Access at this link: https://rdcu.be/b5xev.

Source: Gupta A, Madhavan MV, Sehgal K, et al. Extrapulmonary manifestations of COVID-19. Nat Med (2020). https://doi.org/10.1038/s41591-020-0968-3

Mask Studies

The experts all agree that frequent hand washing, masks and social distancing are key to keeping down the rate of infection. Studies back that up: A meta-analysis of more than 150 studies, recently published in *The Lancet*, found that the chance of transmission when people are less than about 3.3 feet apart is almost 13%, but that drops to 2.6% when they are more than 3.3 feet apart, and double that is even better. And the chance of transmission without a mask is greater than 17%, compared with 3% when a mask is worn.

Source: Chuk DK, Akl EA, Duda S, et al. Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis. Lancet. 2020;395(10242):1973-1987.

If You Don't Have a Mask…

While wearing a mask is now mandated in many places or at least strongly recommended, there are still times where patients or passersby won't be wearing them and won't be practicing good cough hygiene. What to do then? Retired geriatrician Fredrick T. Sherman, MD, MSc, (and former Medical Editor of the journal *Geriatrics*) offered his 3-step technique for warding off the flu and other respiratory illnesses during nearly 40 years of practice.

"Every time I hear or see someone cough or sneeze near me, I quickly do the following 3 maneuvers in rapid sequence:

Exhale: First, I slowly begin to exhale, preferably against pursed lips. Exhaling prevents the inspiration of any droplets and breathing out against pursed lips increases the time it takes to exhale fully, thus allowing me a longer time to physically remove myself from the immediate vicinity of the infected droplets. Never inhale first, as this may bring respiratory droplets into your upper and lower airways.

Continued on page 18

Continued from page 13

Look Away: Second, while continuing to exhale, I look away from the person who has coughed or sneezed. Then…

Walk Away: Third, while continuing to exhale, I walk away from this person if possible. If you can't walk away, at least you have "looked away."

I have trained myself to do these 3 maneuvers quickly, both indoors, such as in subway cars and buses, and outdoors, think crowded streets. Performing this technique has played a part in my remaining free of viral respiratory illness during most of my career."

Source: Sherman FT. Learning to EXHALE. Don't catch the flu this season! Geriatrics. 2008;63(10):2-3.

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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:

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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.)

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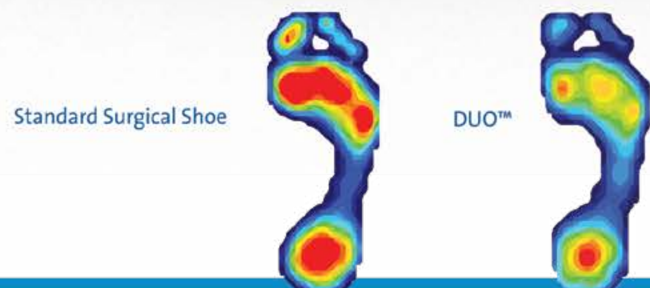

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From the LITERATURE

Cooling Insoles Offer New Approach to Diabetic Foot Ulcer Prevention

A new cooling insole developed by UT Southwestern scientists reduced the foot temperature of patients with diabetic neuropathy by several degrees, diminishing a significant risk factor for diabetic foot ulcers. This new device, detailed in an article published in *The Journal of Foot & Ankle Surgery*, could eventually prevent thousands of diabetes-related amputations each year.

Just in the U.S., more than 100,000 lower extremity amputations take place every year, many of them prompted by diabetic foot ulcers. These ulcers are associated with numerous quality-of-life and health consequences, including a mortality rate of 50% within 5 years for patients who develop them. Although the exact cause of this common diabetes complication is unclear, high foot pressure has long been considered a prevailing cause. Consequently, the most prescribed preventive treatment for diabetic foot ulcers is pressure-relieving insoles.

However, says Metin Yavuz, DEng, an associate professor in the School of Health Professions' Division of Prosthetics and Orthotics at UT Southwestern Medical Center, this prophylactic intervention isn't accomplishing its goal, since diabetic amputation rates have been on the rise despite widely available pressure-relieving insoles. "Even when patients receive therapeutic shoes and insoles, education, and close monitoring," he says, "30% to 40% of patients who have had one diabetic foot ulcer will still develop another within a year."

Hoping to decrease these numbers, Yavuz and his colleagues focused on another risk factor for these ulcers: foot temperature. Animal studies have shown that skin maintained between 25 and 30 degrees C is less likely to break down under pressure than skin at higher temperatures. The feet of diabetic patients already tend to be warmer due to inflammation associated with the disease, Yavuz explains, compounded by friction from walking and the stiff therapeutic shoes that patients wear, which are usually made of synthetic materials that act as heat insulators.

"We thought, why don't we break that vicious cycle by cooling the foot?" he says.

To do that, Yavuz and his lab, aided by a pilot grant from UTSW's Center for Translational Medicine, developed a system that circulates cool water into pressure-relieving insoles. The device—Temperature and Pressure Monitoring and Regulating Insoles (TAPMARI)—is a small box that houses a cooling unit, a small water pump, a battery pack, and a thermostat; the box is worn strapped to the patient's calf. The cooling unit harnesses a type of thermoelectric cooling called the Peltier effect to chill water to a desired temperature that's then pumped into insoles placed in the wearer's shoes. Yavuz later teamed up with the engineering company

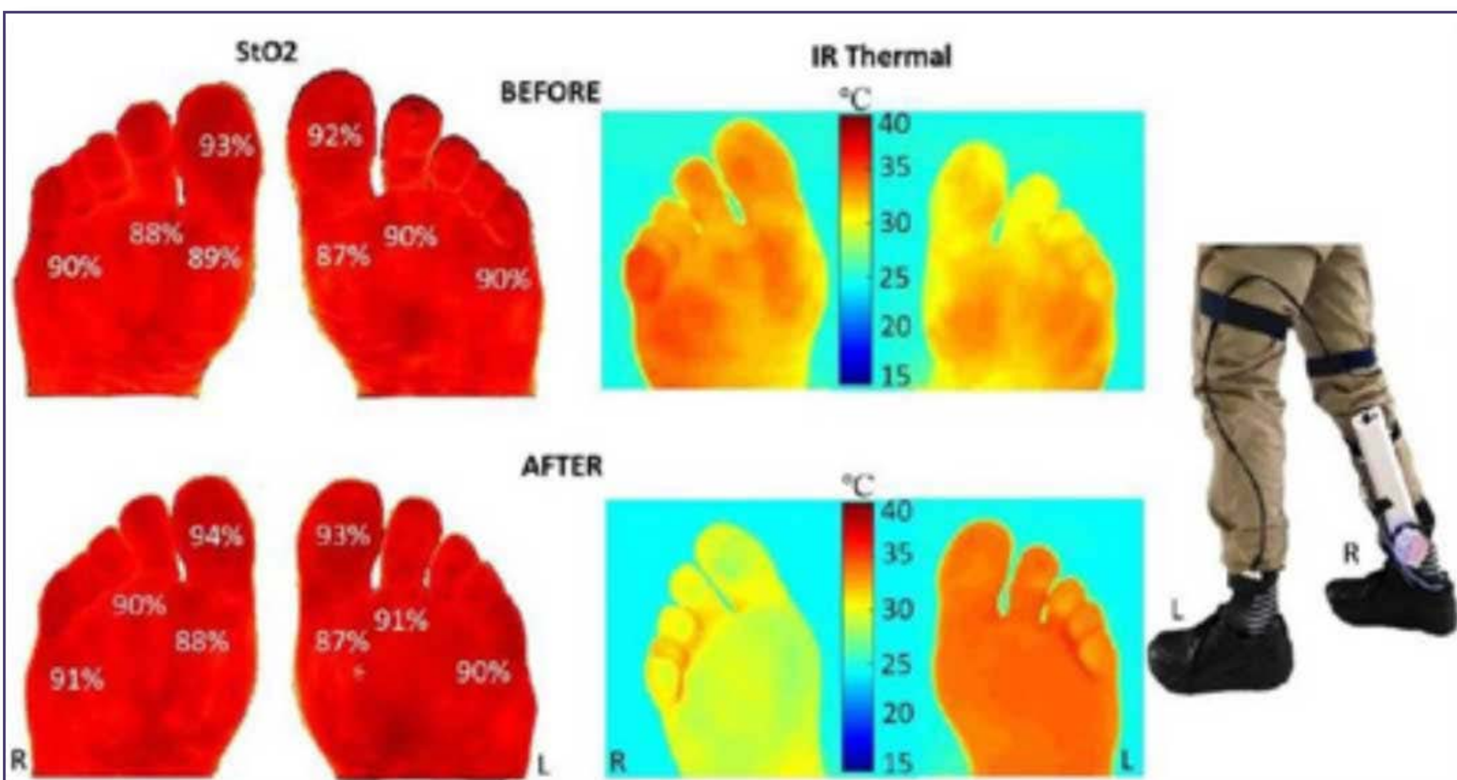

Figure. A representative result of a subject with diabetic neuropathy. Hyperspectral (left row) and temperature (middle row) images collected before and after treadmill walking. TRI in-use (right.) Bilateral temperature reduction is 1.9°C, StO2reduction is 2%. R: Right, with TRI, L: Left, Control shoe.

Continued on page 22

Continued from page 21

Vivonics Inc. and obtained funding from the National Institutes of Health to improve the design.

The researchers tested the improved device in eight volunteers: one man and seven women of a median age of 45 years. Five of these volunteers were healthy and three had diabetic neuropathy.

Using an infrared thermal camera, the researchers took photos of the subjects' feet at baseline before wearing the insoles, then placed a cooling insole in only their right shoes. They took more thermal photos after the subjects walked five minutes on a treadmill and again after they wore the insoles an additional two hours and walked five minutes on the treadmill again.

Results showed that the mean baseline foot temperature in the group was 28.1 degrees C. Mean foot temperatures at the end of the study were 31.7 degrees C for the left foot and 25.9 degrees C for the right, which was cooled by TAPMARI. Although the diabetics' feet got warmer than those of the healthy volunteers during walking, they still maintained a mean temperature of 27.5 degrees C in the right foot, suggesting that the insoles could maintain temperature in a range that protects against skin breakdown.

Cool temperatures from the insoles didn't cause vasoconstriction (narrowing of blood vessels) in the foot, which could have damaged tissue, Yavuz says. However, sole temperatures reached as high as 30.8 degrees C in some regions of the cooled feet, particularly in the midfoot, suggesting that the design of the insole needs to be improved. Other design elements could also be tweaked, he says, such as reducing the size of the unit worn on the calf.

Eventually, Yavuz says, these devices could change the course for patients with diabetes, preventing this common and often serious complication.

"Diabetic foot ulcers can be a major burden on patients, their families, caregivers, and the health system," he says. "What we're doing now to prevent these ulcers or simply maintain the status quo isn't working. TAPMARI could be the start of a whole new approach."

Other researchers who contributed to this study include Ali Ersen and Lawrence A. Lavery of UTSW; Aakshita Monga and Yasser Salem of the University of North Texas Health Science Center; Alan Garrett of the John Peter Smith Hospital; and Gordon B. Hirschman and Ryan Myers of Vivonics Inc.

This research was possible due to support from the National Institutes of Health under grant number: 1R43DK109858-01A1. None of the funding or supportive agencies were involved in the design or conduct of the study; collection, management, analysis, or interpretation of the data; or preparation, review, or approval of the manuscript. Yavuz, Hirschman, and Ersen have a patent pending on TAPMARI.

Source: Yavuz M, Ersen A, Monga A, et al. Temperature- and Pressure-Regulating Insoles for Prevention of Diabetic Foot Ulcers. J Foot Ankle Surg. 2020;59(4):685-688. doi:10.1053/j.jfas.2019.05.009

Sjogren's Musculoskeletal Pain Not Related to Enthesitis

An assessment of entheses involvement using ultrasonography has found that musculoskeletal pain in patients with Sjogren's Syndrome is not due to enthesitis. This prospective study included 25 Sjogren's female patients (mean age, 53.2 + 11.3 yrs) and 25 sex and age-matched controls (mean age, 50.6 + 9.7 yrs), who all underwent an ultrasound (US) examination using gray scale and Doppler US. Researchers looked at 5 sites—distal quadricipital, proximal patellar, distal patellar, distal Achillian, and distal brachial tricipital—to determine the presence of hypoechogenicity, thickening, loss of fibrillar structure, erosions, enthesophytes, calcifications or Doppler hypervascularization. Sjogren's patients had a lower number of entheses pathologies on ultrasound (3.92 + 1.93) compared to the control group (4.52 + 2.27) (P>.05) as well as a lower total score of enthesitis abnormalities (4.96+2.59 vs 5.72+2.92; P>0.5). The total score of enthesitic abnormalities seen on ultrasound was positively correlated to age in both the Sjogren's and control groups.

Source: Abdelghani KB, Miladi S, Chammekhi M, et al. Entheses ultrasound assessment in primary Sjogren's Syndrome. Joint Bone Spine. 2020;87(4):337-341.

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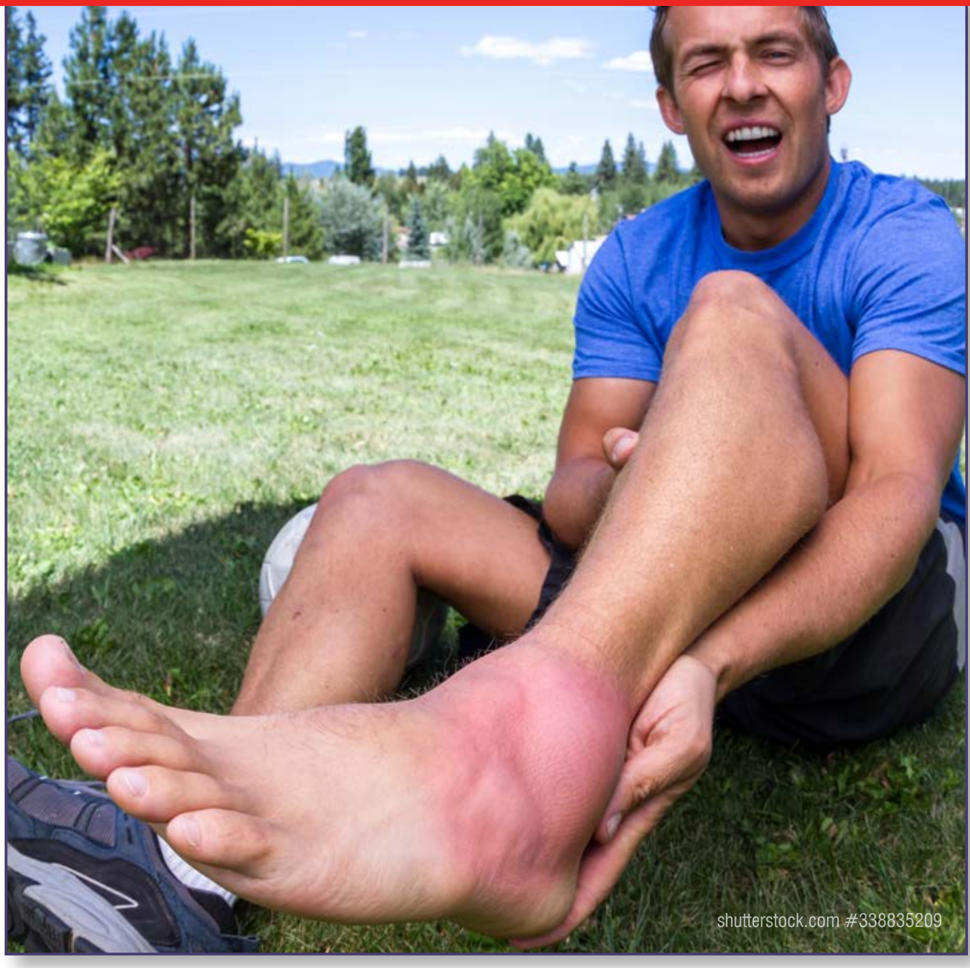
Peroneal Tendonitis: Workup and Nonsurgical Treatment



More than "just a sprain," accurately diagnosing peroneal tendonitis in a timely manner helps patients recover faster and avoid long-term sequelae from this painful condition.

By Kevin Haag, DPM, PGY-3, and Marshall Solomon, DPM

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Peroneal tendon disorders have traditionally been considered a rare source of ankle symptoms. However, contemporary studies have brought the significance and frequency of peroneal pathology to light. It is critical to assess the patient for peroneal tendon pathology, including peroneal tendonitis. This condition can be a challenge to accurately diagnose as it is often overlooked in the face of the ever-present ankle sprain. Unfortunately, missed diagnoses or delayed treatment are associated with long-term sequelae.[1] Developing a knowledge of the anatomy, epidemiology, diagnosis, and treatment of peroneal tendonitis is crucial for providing comprehensive care.

Anatomy and Normal Function

Both peroneus longus and brevis tendons begin their course along the lateral compartment of the leg and curve around the lateral malleolus in the peroneal tunnel together before heading separate ways to perform different tasks in the foot. They are separated at the peroneal tubercle on the calcaneus. The peroneus brevis tendon then inserts distally onto the base of the 5th metatarsal at the styloid process, while the peroneus longus tendon curves plantar to the peroneal sulcus of the cuboid bone and heads medially to insert onto the plantar lateral aspect of the medial cuneiform and first metatarsal base.

These tendons perform critical roles in balancing the foot and ankle. Both tendons are powerful everters of the foot. They serve this function during midstance and propulsion during the normal gait cycle. They also serve to stabilize the first ray and 5th metatarsal once contact has been made with the ground. In the face of excess strain on a foot or ankle, they both dynamically stabilize the lateral ankle complex to prevent damage and injury.

How Damage Develops

The peroneal tendons can develop pathology due to anatomic variants, direct and associated injuries, and altered biomechanics.

There are several known anatomic variants that increase the chance of a patient developing peroneal pathology. The concept of "overstuffing" of the peroneal tunnel has been mentioned as an important factor of anatomic variation leading toward peroneal tendonitis.[1] Anatomic variations, such as a low-lying muscle belly (when a peroneal muscle extends past the tip of the lateral malleolus), accessory peroneal muscles, and altered shape of the retro-malleolar groove, can all create this effect.[1,2,3] Other anatomic variants that can increase the risk of peroneal tendinopathy include a prominent peroneal tubercle and a calcified os peroneum.[4,5] It is important to realize that, although variants exist, they are not a guarantee of pathology. In fact, a study of patients with asymptomatic feet and ankles revealed 72% possessed abnormal peroneal anatomy.[3]

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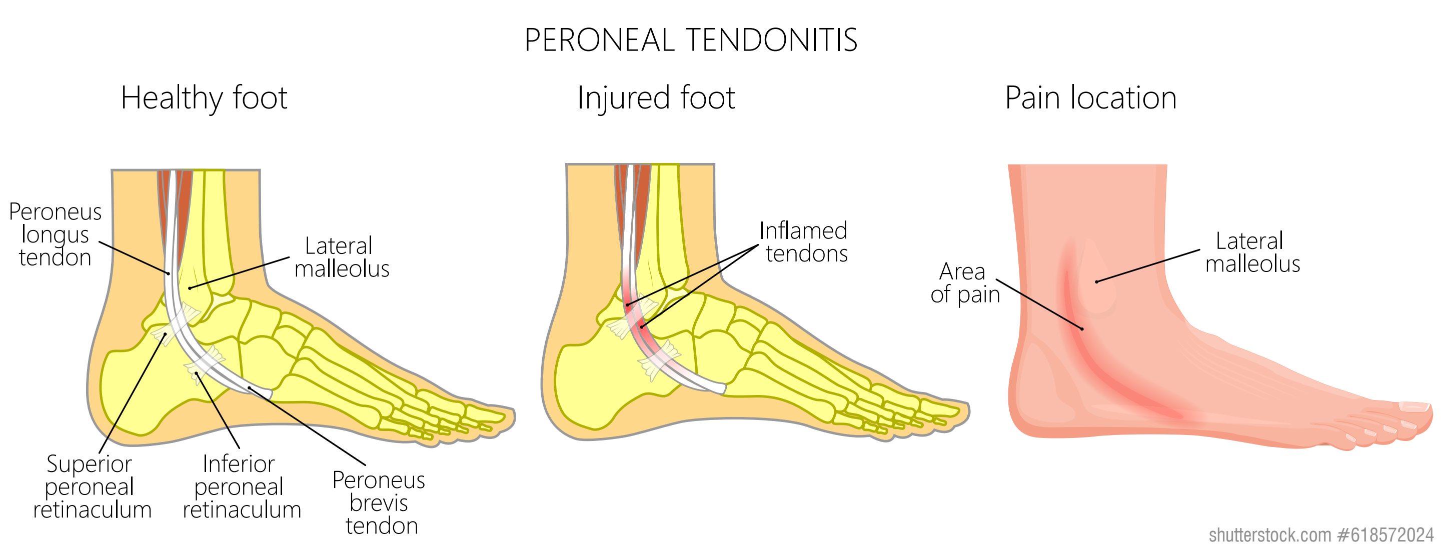

It must be stressed that the peroneal tendons are designed to work in conjunction with an intact and healthy lateral ankle complex, as well as a biomechanically functional foot. If the lateral ankle (lateral ligaments and superior peroneal retinaculum) has been damaged, the peroneal tendons must shoulder an increased workload to keep the ankle stabilized throughout the gait cycle. This overuse results in inflammation and tendon damage. In fact, one classic study found that 77% of patients with a history of chronic ankle sprains and instability had inflammation in or around their peroneal tendons.[6]

Biomechanically, planovalgus and cavovarus deformities are often associated with peroneal tendon pathology. These foot types enable these tendons to experience overuse or compression-type injuries along their course.[7] Several studies have pointed to the peroneal longus tendon as a major contributor of deformity in cavovarus feet.[8] One study of cavovarus feet found enlargement of the peroneus longus tendon in more than 74% of the cases.[9]

While a history of previous ankle sprains or anatomic variants are common causes of peroneal tendonitis, not all individuals present like this. Other causes of peroneal tendonitis include unsupportive or inadequate footwear in an active individual or a recent significant increase in a new activity or training program that results in high demand on the peroneal complex. Almost all of these instances involve prolonged or repeated activity.

Making the Diagnosis

A comprehensive history is imperative to gain a full appreciation for this diagnosis, and it is important to ask specific and detailed questions about activity and recent changes, as well as acute injury, recent trauma, or chronic repetitive loading leading to injury. Eliciting a history that includes pain-causing activities, the nature of this pain, and localization of the pain will assist with making the diagnosis.

If one suspects peroneal pathology, the physical exam itself is not a challenge; however, it must be thorough. Several studies have found the history and physical examination to be of greater value than advanced imaging or other workup for this diagnosis.[10,11] Patients will classically have pain and swelling along the path of the peroneal tendons. If the pathology has been present long enough, the findings can become more subtle and diffuse. Pain can also become focused overlying the posteriolateral ankle. For isolated inflammation of the brevis tendon, pain will follow the tendon into its insertion at the fifth metatarsal base. Focused inflammation of the longus tendon will often be present along the lateral aspect of the cuboid bone.[12]

A lateral stress test of the ankle can help uncover peroneal pathology. This test can be followed-up by stretching the peroneals via passive inversion and plantarflexion, as well as active eversion and dorsiflexion.[13]

Tools for Further Workup

As noted above, a thorough history and physical examination plays a large role in diagnosis of peroneal tendonitis. However, imaging studies can be used to support and confirm these findings.

Standard X-ray imaging should be obtained during any lateral ankle workup. This can help assess for bone-related sources of the pain, including an abnormal fibular groove, peroneal tubercle, hypertrophic 5th metatarsal base or other findings. Ultrasound imaging can also be a useful diagnostic tool which enables dynamic examination of the lateral ankle ligaments and peroneal tendons. It is cost effective and can be used to compare to the contra-lateral ankle and foot.[14]

Magnetic Resonance Imaging (MRI), considered the gold standard when evaluating the peroneal tendons, allows for clear visualization of the tendons and associated structures including the tendon sheath and excessive fluid found with inflammation. More than 3mm of fluid within the peroneal tendon sheath is considered diagnostic.[15] *However, an MRI is not without faults.* Providers should be aware of false-negatives and false-positives. The famous "magic angle" occurs when a tendon is at 55 degrees

Continued on page 29

Continued from page 26

from the magnetic field. Because the peroneals wrap around the ankle and change angles multiple times, they are at a higher likelihood than other tendons to produce this phenomenon. The magic angle can give the false impression of a tear. However, a truly damaged tendon will also have significant inflammation present.

While conservative therapy can be successful for most patients with peroneal tendonitis, if imaging reveals a hypertrophic tubercle with tendonitis, surgery should be pursued earlier on. Conservative therapy cannot remove this physical source of continual stress and damage to the tendons.[4]

Treatment

The majority of peroneal tendonitis can be addressed without surgical intervention. Early recognition and treatment will increase the odds of successful conservative therapy. However, many times patients presenting with peroneal tendonitis have been misdiagnosed and incorrectly treated in the past. It is critical to explain to the patient why their "ankle sprain" is really much more than a "just a sprain," and what must be done to move toward a positive outcome. Empowering patients with an understanding of their real diagnosis is a powerful tool in any successful healthcare provider's skill set.

Immobilization of the overworked peroneal tendons is a cornerstone of treatment. CAM boots, AFO bracing, or even casting can be utilized to achieve immobilization. Standard protocol with adequate time (usually a minimum of 6–8 weeks) for healing and reassessment should be used. Activity modification and alterations in shoe-gear and training can also be very effective.

Oral NSAIDs can also be safely used as a front-line treatment for this pathology. They are well tolerated in the majority of the patient population experiencing peroneal issues.

A recent study demonstrated that ultrasound-guided corticosteroid injection was relatively effective in patients with symptomatic peroneal tendon tears or tendinopathy. The steroid can be accurately injected into the peroneal tendon sheath offering another means of nonsurgical treatment.[16]

The use of platelet-rich plasma injection (PRP) for treatment of painful tendinopathy has become popular in recent years. While one randomized controlled trial[17] which included PRP injections into peroneal tendons had promising results, a meta-analysis[18] of 13 similar tendinopathy PRP trials found mixed results and no strong indication.

If patients continue to experience symptoms and pain for more than 3 months, extracorporeal shock wave therapy can be considered as a treatment option. A meta-analysis of 13 studies found that shock wave therapy can be a useful treatment modality and should be contemplated when initial nonoperative treatments have failed.[19]

Physical therapy with a focus on balance, strengthening, and proprioceptive rehabilitation can be a very beneficial treatment for both athletes and nonathletes. For nonathletic patients, all physical therapists will be able to provide excellent care. However, it is crucial to set up athletic patients with therapists that have sports medicine training due to their very specific needs.

Overall, conservative therapy tends to work very well in patients with lower functional demands, while patients with higher functional needs, such as elite athletes, may require surgery should conservative therapy fail. This is why developing a rigorous treatment plan that actively involves one's patients is of utmost importance.

While the above treatments are effective tools in the direct treatment of peroneal tendonitis, providers must address contributing pathology if present. If a high school athlete developed peroneal tendonitis that resolved with treatment, it would be short-sighted to allow him/her to resume the exact same training regime without recommendations, modifications, and therapy.

In conclusion, peroneal tendonitis, while uncommon, is a unique pathology that is often misdiagnosed and overlooked. Fortunately, if a provider has a high index of suspicion, it can be diagnosed and managed successfully. It is critical to perform a thorough history and comprehensive examination. This should be followed up with the appropriate imaging studies, including X-rays, ultrasounds, and MRI, as needed. Conservative therapy can then produce excellent outcomes if applied correctly. If these steps are taken, providers can help patients overcome peroneal tendonitis without intervening surgically or developing long-term sequelae.

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A Multifactorial Perspective on Lower-Extremity Amputee Rehabilitation

Limb loss alters pain, touch, and proprioception in countless ways that are not yet fully understood. Understanding how to more realistically evaluate the efficacy of both proactive and reactive interventions meant to address these alterations will improve outcomes and quality of life for those living with lower-extremity amputation.

By Austin Davids, MSOP, CPO, and Jeffrey Yau, PhD

People who suffer lower-extremity amputations contend with a host of sensorimotor complications as they attempt to regain function and mobility. Protective sensation may be irrevocably lost depending on the etiology of the amputation. Most amputees experience pain and phantom sensations. Prosthetic comfort may be complicated in some patients due to issues with their residual limb; prosthesis users must learn to ambulate with reduced and unfamiliar patterns of sensory input. Many complications related to limb loss can be addressed by both proactive and reactive interventions, including surgery, pharmacological pain management, therapeutic strategies, and prosthetic design choices. Emerging technologies, such as advanced neuroprostheses, are also poised to reshape the outcome landscape for this population. Here, we briefly summarize what is currently known of how pain, touch, and proprioception are altered by limb loss and the interventions available to address these complications. We conclude by offering a multifactorial perspective that integrates these components and highlights the critical need to additionally emphasize active sensing and haptics when considering outcomes in lower-extremity limb loss.

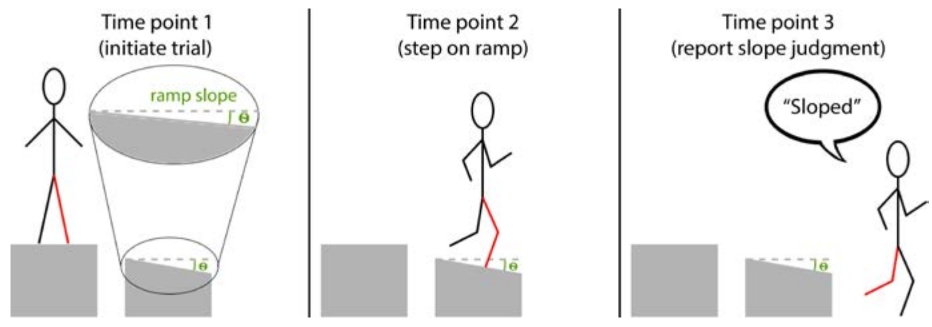

Figure 1. Assessing sensitivity to ground slope. On each trial, the participant steps from a flat platform to a ramp whose slope (θ) is manipulated by the experimenter. The participant then reports whether she perceived the ramp to be sloped or not. Over a series of trials, this paradigm can be used to determine the ramp slope that each participant can reliably identify as sloped.

Residual and Phantom Limb Pain

No matter the cause, an individual who undergoes lower-extremity amputation will experience significant pain that requires management. Amputation-related pain can be divided into two general categories: residual limb pain and phantom limb pain. Residual limb pain refers to pain that is localized at, or proximal to, the amputation level of the affected limb. This includes pre-surgical pain, acute post-surgical pain, and chronic pain from complications associated with adhered scar tissue, neuromas, and heterotopic ossification, among other conditions. Phantom pain is pain that is localized distal to the amputation level of the affected limb. Phantom pain is well-documented in lower-extremity amputees and the neurobiological origin of these painful experiences—which involve signaling in the peripheral and central nervous system—remain the focus of a number of research efforts. For most individuals, even without treatment, the severity and frequency of phantom pain decreases with time; however, such pain can persist in some individuals with devastating effects on quality of life.

> Importantly, prosthetic design choices can substantially influence pain outcomes. Indeed, pain can be minimized with a well-fitting and comfortable prosthesis.

Numerous strategies have been implemented to manage amputation-related pain. Proactive methods, such as the administration of multimodal analgesia regimens that simultaneously target multiple pain pathways, are implemented perioperatively. Such proactive methods can reduce the duration and severity of amputation-related pain, which implies that blunting pain signaling before and during surgery serves as management for both short-term and long-term pain outcomes. Additionally, the specific approaches used during surgery can impact long-term pain experiences; surgical techniques such as targeted muscle reinnervation and targeted sensory reinnervation can reduce the likelihood of neuroma formation and phantom pain complications.

Reactive methods are used both acutely and

Continued on page 34

Continued from page 33

chronically following amputation surgery, with some being more appropriate than others, depending on the cause and severity of the pain. The case has been made for using mirror therapy, transcutaneous electrical nerve stimulation, and percutaneous electrical nerve stimulation to treat amputation-related pain and substantial research efforts are currently aimed at demonstrating the efficacy of these and similar interventions. Non-primary targeted muscle innervation, performed as a revision surgery, can be effective for reducing neuroma-related pain. Importantly, prosthetic design choices can substantially influence pain outcomes. Indeed, pain can be minimized with a well-fitting and comfortable prosthesis, designed with judicious use of gel liners, localized low-durometer reliefs, and volume adjustment systems (eg, RevoFit). Additive manufacturing and other advanced materials, such as silicones and flexible resins, give prosthetists additional tools with which they can design comfortable interfaces for their patients.

As long as the cause of the pain can be correctly identified, in most cases there will be options to manage that pain and maximize the patient's functionality; proactive and reactive methods offer a panoply of pain management approaches.

Effects of Limb Loss on Touch

Limb loss can be associated with dramatic changes in how touch is experienced on the residual limb. Unfortunately, how limb loss affects touch can be inconsistent as there are reports of increases or decreases in tactile sensitivity and complications can arise from either. With increased sensitivity, it may be difficult to achieve acceptable socket comfort, and this can limit the individual's prosthesis use and functionality. With reduced sensitivity, the individual may not reliably report discomfort from their prosthesis. This increases the risk of residual limb ulceration, which has potentially serious consequences. Additionally, impaired touch on the affected lower-extremity and on the intact limb can contribute to poor balance in quiet standing and frequent falls. Changes in touch, which include non-painful phantom limb experiences, may be associated with altered neural activity throughout the afferent nerves, the spinal cord, subcortical centers, or the brain. In some instances, changes in touch may not be due to limb loss, per se, but they may instead be a consequence of other conditions, such as diabetic neuropathy, that impact the health and function of sensory nerves.

Currently, there are relatively limited options for treating aberrant tactile experiences related to limb loss. Hypersensitivity on the residual limb can be reduced, in part, through desensitization exercises. Careful and deliberate prosthetic interface design can also help minimize discomfort. In cases where the sense of touch has been reduced or lost, targeted sensory reinnervation surgery can lead to near-normal skin sensitivity on the residual limb, with said sensations referred to the patient's missing extremity. Crucially, whether and how prosthetic interface design and cutaneous sensing impact a prosthesis user's overall functionality is unknown at this time. This remains a critical knowledge gap and research efforts need to establish a consensus on how best to use the intact and available skin regions after limb loss.


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Effects of Limb Loss on Proprioception

Proprioception is the ability of a person to sense the position and posture of his or her limbs in space. This sense is critical for moving and balancing. Much proprioceptive signaling comes from specialized receptors in the muscles and tendons. The loss of these due to amputation understandably results in an impaired ability to perceive the location or posture of one's limb. Interestingly, proprioceptive deficits may be more evident when individuals respond to passive movements of their limbs as compared to when they move their limbs to produce specific postures. This implies that individuals are able to exploit multiple cues, including signals related to motor control, to perceive their limb state. Because less is known regarding the processing of proprioception compared to pain and touch, even in able-bodied individuals, strategies for treating amputation-related proprioceptive deficits are still being developed and evaluated. Surgical procedures such as targeted muscle/sensory reinnervation and osseointegration have the potential to proactively improve proprioception in lower-extremity amputees. Myoneural interfaces that leverage agonist-antagonist muscle relationships have also been shown to be effective in improving proprioception. Interface design and fit may also contribute substantially to proprioception. Importantly, physical therapists can train lower-extremity prosthesis users on how to interpret proprioceptive feedback to maximize their safety and functionality.

Adopting a Multifactorial Perspective That Emphasizes Functionality

Lower-extremity limb loss has devastating effects on an individual's functionality and quality of life. In the proceeding sections, we have offered a brief summary of how limb loss impacts the experience of pain, touch, and proprioception. We have also reviewed proactive and reactive strategies for mitigating the deleterious effects related to amputation in these domains. While a reductionist perspective, which focuses on pain, touch, and proprioception individually, can be helpful and clarifying, we propose the adoption of a perspective that incorporates multiple factors in evaluating

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the experiences and rehabilitation of lower-extremity amputees. Moreover, we also suggest that research efforts address how individuals with limb loss experience their environment in addition to how they perceive their body. Our preliminary work on the perception of ground slope offers an illustrative example. Volunteers were asked to perform a simple behavioral task requiring them to step on a ramped platform, the slope of which could be adjusted from flat to steep (Figure 1). Each time the participant walked over the platform, they indicated whether they felt that the ramp was sloped downhill. By repeating this process over many different slopes, we were able to estimate how sensitive individuals were to ground slope differences and how this sensitivity differed between legs (Figure 2). Our preliminary results indicated unilateral transtibial prosthesis users had impaired slope sensitivity on their prosthetic side compared to their sound side. In contrast, control participants had similar sensitivities on their dominant and non-dominant legs. Importantly, beyond simply confirming the presence of impaired ground slope perception, our method allows one to quantify the degree of functional impairment in a more behaviorally relevant context. Conceivably, this more precise assessment may be helpful in evaluating the efficacy of the proactive and reactive interventions described above.

In conclusion, while it has been useful to evaluate the impact of lower-limb loss on how amputees experience their body, we recommend that these efforts be complemented by efforts to gauge how limb loss impacts more naturalistic behaviors. How the effects of limb loss on pain, touch, and proprioception relate to active behaviors, such as walking and ground slope perception, is an open question. Answering these questions will hopefully inform the development and refinement of rehabilitation strategies for improving the function and quality of life for lower-extremity amputees. ler

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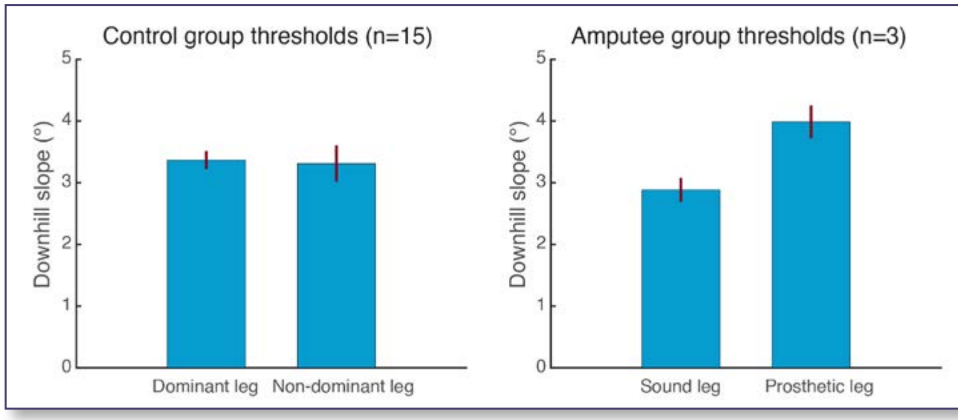

Figure 2. Slope perception with sound and prosthetic limbs. (Left) Participants with 2 sound limbs had similar slope perception thresholds with their dominant and non-dominant legs. Higher thresholds indicate reduced sensitivity to differences in ramp slope. (Right) Participants with limb loss were able to perceive ramp slope using their prosthetic limb, albeit with higher thresholds compared to their sound limbs.

This work is based on a poster by the same authors ("A Novel Method to Quantify the Haptic Perception of Slope") that was presented at the 45th Annual Meeting & Scientific Symposium of the American Academy of Orthotists and Prosthetists held in Orlando, Florida, in early March 2019.

ARTICLES OF INTEREST

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Targeted Muscle Reinnervation/Targeted Sensory Reinnervation

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Importantly, physical therapists can train lower-extremity prosthesis users on how to interpret proprioceptive feedback to maximize their safety and functionality.

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Recovery and Regeneration Strategies for Foot Performance: Part I

These 2 complex processes are necessary components of quality training programs for athletes at all levels. This article, which covers fundamentals, is the first in a 2-part series.

By Antonio Robustelli, MSc CSCS

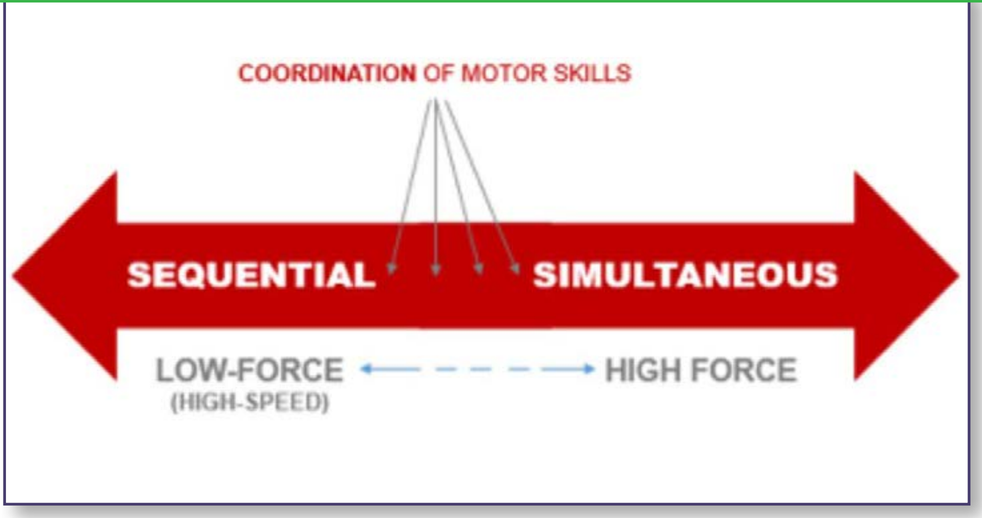

Figure 1. The existing continuum between sequential (low force) and simultaneous (high force) muscle actions.

Taking care of the recovery and regeneration of the foot is an integral part of a well-rounded approach to high performance development.

To start, recovery, from a global and general point of view, is a necessary consequence of training (ie, stress application). It cannot be seen as a separate entity as all the physiological processes involved in its progression are strictly related to each other despite having different times for return-to-baseline and compensation.

Second, specific recovery and regeneration of the feet is required to allow adequate function of all the complex structures handling the mechanical load and stress of daily training and extracurricular daily life activities.

For mechanical stress, we refer to the complex quantity (symbolized with the σ) measuring the intensity a load is exerting on a material to change its shape: when talking about the foot, this mechanical stress, which has the same unit of pressure (N/cm2), is a reflection of how much load is exerted at the structural level (bones, joints, soft tissues) in the anatomical region of the foot and ankle complex.

For the sake of proper biomechanical understanding, mechanical stress is a complex quantity called a tensor, which is a generalized vector with multiple directions[1]: the stress is the force applied per unit area of the tissue and the strain "indicates the change in length of the tissue relative to its initial length."[2]

Given that the biomechanical and performance output of the foot/ankle complex is a consequence of proper function and structural integrity of the tissues contributing to foot stiffness during locomotion *(plantar aponeurosis* and *windlass mechanism* representing 2 of the most important), having an optimized protocol is of utmost importance to ensure all the structures surrounding the foot—and handling all the force and power output exerted by the major muscle groups involved in each movement pattern—recover and regenerate properly.

While the concept of stiffness and the stress-strain relation are outside the scope of this article, it should be clear that foot structures receive a great amount of mechanical stress and tissue deformation that needs to be taken into account when considering priorities for recovery.

> The foot is the complex structure enabling the optimal expression of movement efficiency and proficiency needed for high performance.

Recovery and Regeneration: Differences in Terminology

Although the 2 terms are often used interchangeably, there is a thin line differentiating the 2 concepts from a methodological and physiological point of view.

In an international Consensus Statement published on 2018,[3] recovery is defined as a *"multifaceted restorative process relative to time;"* further, it is *"an umbrella term, which can be further characterized by different modalities of recovery such as regeneration or psychological recovery strategies."* The authors define regeneration as *"the physiological aspect of recovery which follows physical fatigue induced by training or competition."*

By looking at the evidence as well as on-field application, I suggest the following definitions for practical everday use:

Recovery is the necessary physiological response consequent to the training-induced fatigue and it represents the systemic biological output of the human system in order to compensate and restore the homeostatic balance. It doesn't care about the various sub-systems involved in the process.

Continued on page 40

Continued from page 39

Regeneration is a more specific term that takes into account the local response to stress in terms of magnitude and timing of the various sub-systems involved in the training/stress application process (glycogen restoration, thermal response, neurological function, soft tissue properties, etc.). In summary, regeneration includes all the different strategies adopted to improve (and not necessarily accelerate) the quality of the recovery cycle.

Regeneration Strategies for the Foot and Movement Proficiency/Efficiency

Movement proficiency and efficiency, defined as a result of body/joint positioning (kinematics), tissue status, and force application (kinetics), can only be accomplished by optimally integrating the coordination of motor skills (Figure 1) with segmental interaction (ie, the optimal force transfer through the various joints and body segments).

We keep our regeneration strategies for the foot/ankle complex as a focal point of the overall recovery process because the foot is the complex structure enabling the optimal expression of movement efficiency and proficiency needed for high performance.

Our regeneration protocols for the feet are structured over 3 levels/layers:

1. Structural (Tissue recovery)
2. Functional (Functional movement recovery)
3. Sensory (Skin)

In Part II of this series, I will explain why we target these 3 levels and provide specific methods and techniques used for each protocol. ler

Antonio Robustelli is a professional sports performance consultant and elite coach from Italy; his areas of expertise include injury prevention, sports technology, strength training programming, speed development, recovery monitoring, and return to play assessment. He has worked worldwide for nearly 20 years with semi-professionals, professionals, and Olympic athletes as well as professional teams in various disciplines. Regularly invited as a Keynote Speaker for international conferences in Sports Science and Strength & Conditioning, he is currently a consultant for Federations, Governing Bodies, Olympians and for First Division football and basketball teams in Europe, Asia, and USA. He is a member of the LER Editorial Advisory Board and can be reached at Antonio.robustelli@omni-athlete.com.

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Manipulation of the Myofascia: Motivations, Methods, and Mechanisms

Foam rolling and roller massage, instrument-assisted soft tissue mobilization, and percussion massage are all the rage amongst consumers all along today's fitness continuum. But what is the evidence base for the countless claims proponents offer? These authors provide a review of the peer-reviewed literature.

By Linden A. Lechner, BSc; Michael A. Rosenblat, PT, PhD(c), CEP; and Leanne M. Ramer, PhD

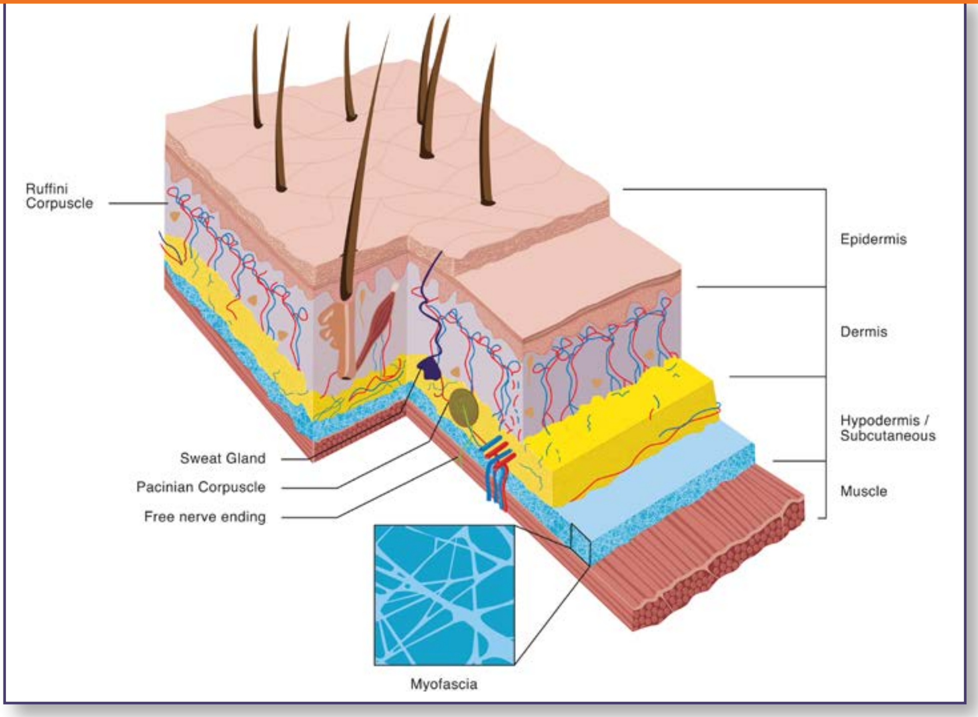

Figure 1. A schematic illustration of the skin and muscle, indicating the relative position of the myofascia, as well as specialized sensory end organs and free nerve endings. (Drawn and designed by Sam Wallbank.)

Over the last two decades, our understanding of fascia has shifted dramatically. Once assumed to be a passive connective tissue, fascia is now appreciated as a mechanically active, innervated, and dynamic system, interacting intimately with muscles to crucially influence their function.[1] While an anatomical consensus and categorization of fascia remains elusive, the anatomical and functional association between fascia and skeletal muscle is commonly described as the myofascia (Figure 1).

In parallel with our increasing understanding of how fascia modifies movement, treatments targeting the myofascia have emerged as a popularized approach to rehabilitation. A subset of this pervasive practice is widely referred to as "self-myofascial release," a collection of treatments that aim to address dysfunctions of skeletal muscle and connective tissue by the consumer at home. These are marketed to mimic the results of manual therapy, with an ever-increasing array of commercially available tools enticing and empowering consumers by creating the feeling that they have a therapist in the palm of their hand.

The term "self-myofascial release" emerged from the suggestion that these manipulations target clinically relevant and painful myofascial trigger points, caused by focal fibrous adhesions or constrictions. Despite the ubiquity of the term in training and rehabilitation, there is little (if any) evidence to support this hypothesis: while many interventions can alter myofascial tone, the mechanism likely has little to do with adhesion "release."[2] We therefore use the more general term myofascial manipulation to describe a growing collection of these techniques.

Of the available options targeting the myofascia, the most popular recent modalities include myofascial rolling, instrument-assisted soft tissue mobilization (IASTM), and percussion massage. These are abundantly and haphazardly used, but the data to support their benefits or best practice for use are only beginning to emerge. With most clients intrigued by or already performing at-home treatments targeting the myofascia, it is critical to understand what literature exists

We found that a minimum dose of 90 seconds per muscle was most reliable for reduction of muscle pain/soreness

Continued on page 44

Continued from page 43

surrounding their efficacy in improving function and promoting recovery. In this article, we discuss the current literature surrounding the efficacy of these techniques, and further explore possible explanations for the outcomes we see with their application.

Foam Rolling and Roller Massage

The most accessible approach to lower-body myofascial manipulation for most clients is myofascial rolling using a foam roller or a hand-held roller massager (or "stick"). Since they are typically touted as recovery tools, rollers and sticks are often used after (or between bouts of) exercise. Massage with a foam roller involves rolling along the length of the targeted muscle or fascia on the device, using body weight to dictate the treatment pressure.[3] The same concept applies to using a roller massager, except the pressure is applied using the upper limbs.

While myofascial rolling has become entrenched as common practice in training, rehabilitation, and physiotherapy, its efficacy is still being investigated in the literature, and the results remain far from clear. This ambivalence is due in part to substantial variability in the available data. The tools themselves vary widely in terms of their construction; they are available in a wide variety of shapes, sizes, densities, and textures. The dose of myofascial rolling inevitably varies with subcutaneous fat mass, as a thicker layer of subcutaneous fat hinders access to the deep fascia and distributes pressure over a larger surface area (Figure 1). In addition, the field is complicated by a lack of consensus on best practices; factors such as effective duration and timing of treatment targeting different regions remain ill-defined.

Purported benefits of myofascial rolling include improved range of motion, reduced muscle soreness, and improved athletic performance. In an attempt to provide some evidence-based consensus on best practice, we reviewed clinical studies that compared the efficacy of myofascial rolling to a control, using at least one of these three outcome measures.[3] The studies that met all of our inclusion criteria (22) examined myofascial rolling applied to the gluteals, the hip flexors, the quadriceps, the hamstrings, the iliotibial band, and/or the plantar flexors.[3]

In addition to the heterogeneity of the available data, we were struck by the duration of myofascial rolling required to confer measurable benefit: we found that a minimum dose of 90 seconds per muscle was most reliable for reduction of muscle pain/soreness.[3] The data on range of motion were less clear; while some evidence of improved range of motion was detected, there was no clear evidence of dose-response, and the variety of tests used to measure range of motion made comparison across studies extremely difficult. For similar reasons, we were unable to detect any effect of myofascial rolling on athletic performance, either detrimental or beneficial. Perhaps most notably, nearly all studies noted that beneficial effects on pain and range of motion were transient (lasting <24–72 hours), strongly suggesting that myofascial rolling produces only short-term recovery.

The issue of whether and how myofascial rolling alters performance remains contentious. In a 2019 study, Laffaye et al examined effects of myofascial rolling immediately following high-intensity interval training (HIIT). On the treated side, participants performed foam rolling over the iliotibial band and the quadriceps, aiming to achieve a 7/10 for pain intensity on the visual analog scale.[4] Foam rolling produced a significant reduction in muscle soreness and increased hip range of motion (measured at 48 hours after exercise), but conferred no detectable benefit on recovery of performance.[4] This study supports the use of myofascial manipulation for reducing soreness rather than regaining initial performance following HIIT.

Several recent studies address specific questions surrounding myofascial massage. For example, Cheatham and Stull examined the effects of foam roller surface texture.[5] They found that two-minutes of quadriceps rolling with a textured (GRID) roller produced larger increases in knee range of motion and quadriceps pressure pain threshold than a less-textured (multi-level) roller or a smooth roller. These effects were measured immediately after foam rolling and without exercise; however, this study provides evidence from a well-controlled setting that the texture of myofascial manipulation tools alters the effects of treatment.[5]

Recent research is also exploring the efficacy of myofascial rolling as a conjunct recovery practice. Oranchuk and colleagues compared the effects of foam rolling, superficial heat, and both together on hamstring flexibility (measured via passive straight leg raise) in 22 female collegiate lacrosse and soccer athletes.[6] Interestingly, they found similar improvements in hamstring flexibility (ie, increased hip flexion) with either superficial heat or foam rolling. Together, combined superficial heat and foam rolling produced the greatest benefits for hamstring flexibility, but the effect was not significantly different than superficial heat applied alone.[6] This raises the important question of whether myofascial rolling produces additional benefits over established recovery practices, particularly those that are non-invasive and low-cost (or free).

Instrument-Assisted Soft Tissue Mobilization

Instrument-assisted soft tissue mobilization (IASTM) refers to a wide range of techniques using metal implements designed to provide a mechanical advantage for deep tissue penetration.[7] This practice has its roots in Gua sha, a traditional Chinese therapy that aims to "scrape or rub the surface of the body to relieve blood stagnation."[8] Accordingly, the procedures are often described as "scraping massage," and are performed using an ever-increasing array of specialized instruments, including commercially available lines such as Graston, Técnica Gavilán, Adhesion Breakers, and many others. The tools for IASTM are expensive, in the price range of

Continued on page 46

Continued from page 45

thousands of dollars for a 6-piece set; this marketing is often coupled with for-profit continuing education courses.[8]

Despite its widespread use, there is little evidence-based consensus around any aspect of IASTM, including indications for its use or its efficacy.[7] Some research is slowly emerging, but the field is plagued by the same issues that surround foam rolling and roller massage, namely, a variability in tools, techniques, and timing of treatment, as well as treated populations. In addition to these confounds, IASTM (as high-pressure shearing treatment) involves more risk for tissue damage than its rolling counterparts. Recent expert commentary highlights the importance of safety guidelines and contraindications for IASTM; an example of the ongoing debate across practitioners is treatment-induced effects on the skin.[7] Some IASTM treatments produce ecchymosis (bruising) and/or petechiae (reddish spotting); in fact, among some practitioners this remains a goal of treatment. However, an increasing number of practitioners regard this as potential iatrogenic tissue damage, which should be avoided or at least healed prior to resuming treatment.[7]

The data on effects of IASTM have been summarized in 2 recent and comprehensive literature reviews:[7,9] in both, the gap between evidence for and implementation of IASTM is obvious. Tentative hypotheses surrounding the benefits of IASTM suggest that it stimulates inflammation and the breakdown of scar tissue, promoting healing and functional normalization.[10] However, data demonstrating either mechanistic or clinically meaningful benefits are limited. In fact, a study of human gastrocnemius found no increase in intramuscular inflammatory markers in muscle biopsies collected 24 hours after IASTM.[11] Most available evidence of efficacy, while intriguing, is derived from small studies, many conducted with a no-treatment control, rendering the findings ambiguous. When the quality of research design is considered—including discerning between statistically significant and clinically meaningful effects—and the potential for bias is acknowledged,[7] the current evidence does not support the use of IASTM as an effective

Figure 2. Application of percussion massage.

treatment to improve client or patient outcomes. These findings are seemingly contradictory to the claims found on the Graston website which boast that Graston tools are effective in "treating all soft tissue conditions, whether they are chronic, acute or post- surgical... restoring range of motion, eliminating pain, and restoring normal function."[12] While it is clear that more research is required, IASTM will have to emerge as obviously superior to roller massage to justify its high cost and potential for tissue damage. This is epitomized in a recent study that directly compared the effects of IASTM and a roller massage stick on hamstring range of motion and concluded that "IASTM and the roller massage stick were equally effective immediately and over time, but the roller massage stick is more affordable."[13]

Percussion Massage

Percussion massage therapy is rapidly gaining popularity among professional and recreational athletes. Multiple tools (or "guns;" Figure 2) have been marketed to, and widely adopted by, athletes to help improve their performance or sport-related recovery. The major companies in this market, including Hyperice Hypervolt, Theragun, and TimTam, have developed percussion massagers for commercial purposes. As a trailblazing technique purported to promote recovery, it is no surprise that percussion massagers are somewhat expensive, typically falling somewhere in-between the relatively affordable tools for myofascial rolling and the high-priced tools and training for IASTM. For example, the TimTam massager is marketed at ~$300, the Hyperice Hypervolt at ~$350, and the Theragun Pro at ~$410.[14]

In part due to their relatively recent appearance, data demonstrating the clinical benefits or physiological effects of any device for percussion massage are slim-to-none. Dozens of online articles boast that these tools stimulate, inter alia, muscle fibre repair, improve lymphatic and venous flow, and break down intramuscular or myofascial adhesions. However, there is no evidence in the peer-reviewed literature to support any of these claims. There is also no evidence to support the safety of this practice, nor are their guidelines to limit intensity or duration of percussion.

Given the new-found popularity of percussion massage, our laboratory recently purchased one of these devices to investigate its efficacy in recreational athletes. So far, we have only anecdotal (athlete-reported) evidence to support acute percussion massage for reduction of post-exercise muscle soreness. We have institutional ethical approval to investigate this

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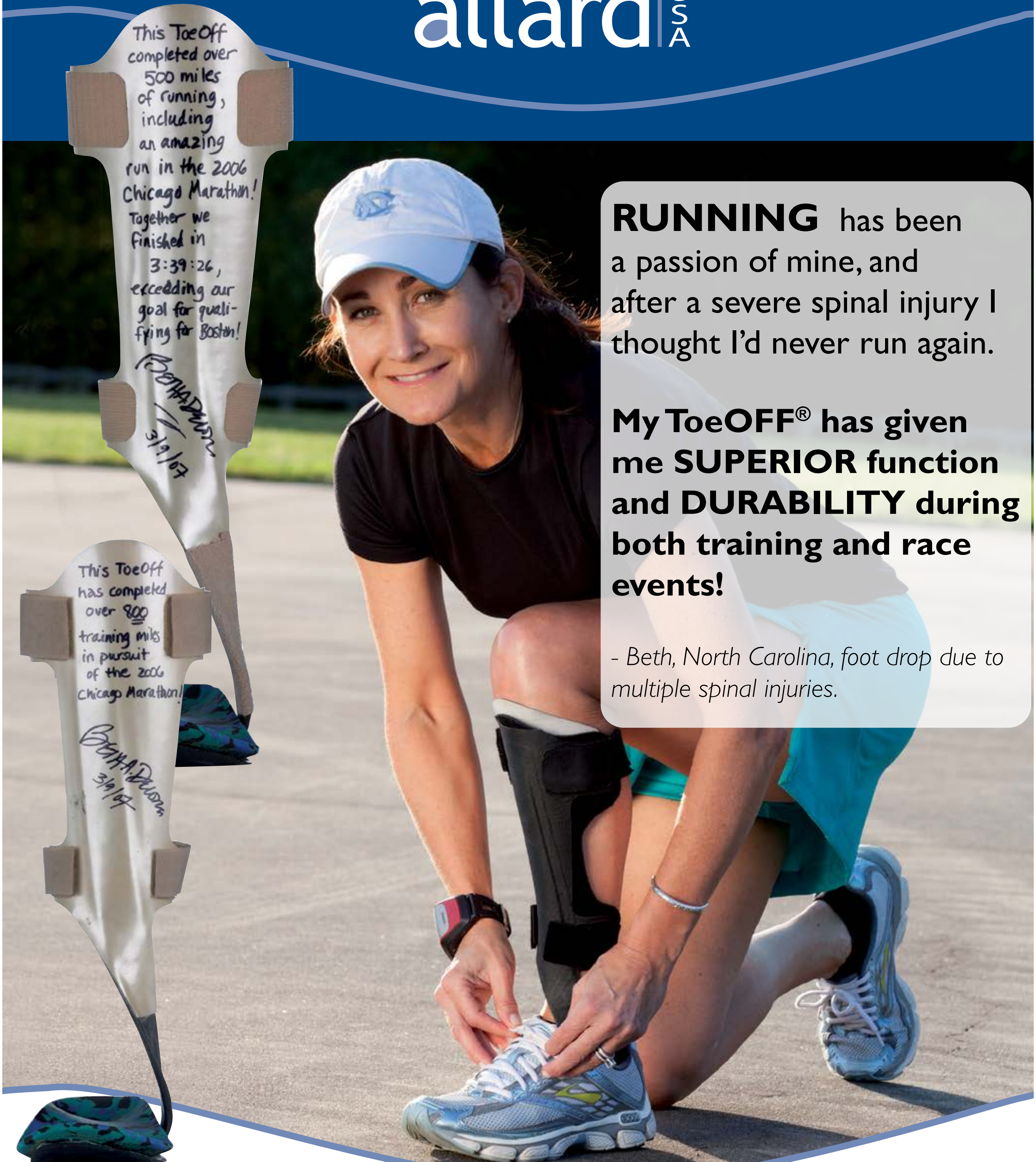

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Continued from page 46

hypothesis, comparing percussion massage to standardized stretching and myofascial rolling, using both range-of-motion and muscle soreness reported via the visual analog scale. We hope these and similar studies will help close this gap between evidence-based therapy and implementation.

Mechanisms of Myofascial Manipulation

If "myofascial release" is a misnomer, and soft tissue adhesions are not affected by myofascial manipulation, what might underlie the benefits of and/or commitment to these practices? Like many interventions, it is likely that benefits of myofascial manipulations are produced by a combination of effects. Certainly, the painful and/or pleasurable experience of myofascial rolling, IASTM, and percussion massage produces a perceived benefit for some clients. This may produce a placebo effect of treatment, or it may simply be enjoyable, thus improving compliance with some type of active recovery routine. While most studies report that myofascial manipulation is superior to untreated control, data demonstrating benefits beyond well-established approaches to recovery remain limited. This is under-scored in a recent meta-analysis of 26 studies examining acute effects of foam rolling on range of motion: foam rolling was superior to no-exercise control, but comparable to stretching.[15]

Rather than altering the structural or mechanical properties of the deep fascia, recent data suggest that neural effects of manipulations targeting the myofascia are paramount to changes in perception and range of motion. A detailed discussion of these collective findings and hypotheses is eloquently presented by Wiewelhove and colleagues.[16] One proposed mechanism is the cutaneous mechanoreceptor's contribution to local relaxation.[2] A variety of specialized mechanoreceptors—Merkel receptors, Meissner and Pacinian corpuscles, and Ruffini endings—have end-organs in the skin (Figure 1). Unlike the relatively deep myofascia, these cutaneous and subcutaneous receptors are readily accessible to treatment applied to the skin. While these receptors differ in their receptive field size, adaptation patterns, and duration of response, their primary function is facilitating proprioception; it is likely they underlie a neural inhibition response for muscle relaxation.[2] Specifically, Ruffini and Pacinian corpuscles may reduce global sympathetic activity, thus decreasing muscle tautness.[2] All 4 of these receptors should display increased activity during delivery of myofascial manipulation. Additionally, general massage can activate the parasympathetic nervous system universally. Both this reduction of the sympathetic drive from receptors and increase in parasympathetic from massage, may in part, explain the reduction in pain with myofascial manipulation.[2]

> This study provides evidence from a well-controlled setting that the texture of myofascial manipulation tools alters the effects of treatment

In addition and intriguingly, recent data demonstrate that the deep fascia itself is innervated, containing peptidergic-free nerve endings (putative nociceptors).[17] This raises a crucial question: does myofascial manipulation mobilize the myofascial unit, or does it simply dampen the nociceptive response, allowing those with limited range of motion due to pain to move beyond their baseline measurements? The neural aspects of myofascial manipulation have captured our attention and remain an open and important area of research, with implications for a variety of health practitioners and their clients who engage in these practices at home.

Provided myofascial manipulation does not produce tissue damage or compromise performance (which remains open to debate), the most pressing questions are at least two-fold. First, does any form of myofascial manipulation out-perform well-established recovery practices, including stretching? If so, are low-cost, accessible manipulations (such as myofascial rolling) comparable in efficacy to higher-cost manipulations? Clinically and practically, it is crucial to consider the disadvantages of any ineffective treatment, including costs, safety risks, and delaying access to beneficial treatment. At present, there is little-to-no high-quality evidence demonstrating clear benefits of myofascial manipulation over well-established recovery practices. There are also no evidence-based guidelines for choosing or applying a method of treatment targeting the myofascia. Practitioners and coaches should be transparent with their clients and acknowledge these limitations: myofascial manipulations may confer benefit, but there is no good evidence that this benefit exceeds traditional approaches to recovery. ler

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Continued on page 50

Continued from page 49

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Using Functional Movement Assessments to Prevent Lower Extremity Injuries

By Sami Ahmed, DPT, CES, SFMA, CMTPT

It seems like every time sports analysts talk about the most recent game—whether it's football, basketball, baseball, college, or professional—they're discussing another athlete's season-ending injury. While the spectrum for the severity of injuries varies, athletes—individuals who we perceive to be in peak physical condition—often find themselves sidelined due to a vulnerability or weakness that is inherent in their body. The sports industry has also recently seen an increase in lower extremity injuries that start out minor, yet when the athlete attempts to play through the pain, the injury escalates and often requires more time off, more physical therapy, or even surgery.

Take Kevin Durant as an example. His March 2019 ankle sprain ultimately resulted in an Achilles tear in June 2019. One year later, he is easing back onto the court as part of his rehabilitation, announcing that he has no intention of returning before the 2021 season. Or Klay Thompson. He started with a hamstring strain and kept playing, which ultimately led to an ACL tear that kept him out for an entire season. It would appear that all lower extremity injuries should be taken seriously so as not to be exacerbated, regardless of how minor they may seem.

Of course, in high-energy sports, injuries cannot be avoided and prevention is never guaranteed. The good news is, diagnostic tools are available that, when used collaboratively, provide critical information about an athlete's movement and strength. In turn, that information can be used to help develop injury prevention strategies for all, and specifically can serve as a baseline to determine if an athlete is ready to return to play after an injury.

First, Think Prevention

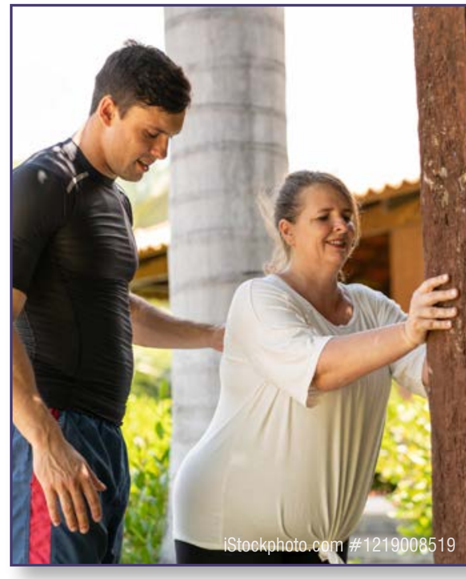
Injury prevention and pre-injury testing are key components of a successful sports medicine program. While prevention comes in many forms, it is important to remember the distinction between prevention and prediction when using diagnostic tools with patients. In my practice at The Centers for Advanced Orthopaedics, I typically use the Functional Movement Screen (FMS) and the Selective Functional Movement Assessment (SFMA)[1] with my patients. Both tests are used to closely analyze specific body movements and aim to predict the likelihood of an injury and provide insights as to what an athlete needs to do to reduce this risk.

These functional assessments are used as an overall evaluation of bodily movement. When looked at as a whole, the body can be split into left and right hemispheres straight down the middle. While every human naturally has a side that is more dominant, there should be relative symmetry between the two sides in a healthy athlete. Improper or too much training in the days, months, or even years before an injury, as well as genetics and other variables, can cause asymmetry to occur in the body. While the athlete's body may be able to handle imbalance for a while, it is likely that eventually, such asymmetry will lead to injury. A classic example of this asymmetry occurs when one knee is significantly stronger than the other. In this case, the ankle is taking the brunt of the force that imbalance creates, and could result in a tear.

Functional assessments aim to find the differences between the body's two hemispheres and identify how movements vary on each side. This allows us to correct them and best prepare the body for an extreme athletic event—a football game, for example—and ultimately prevent instances that may result in injury – like Kevin Durant's Achilles tear I previously mentioned.

Functional Assessments Defined

The FMS is a basic tool used to identify imbalances in mobility and stability by evaluating an athlete's ability to perform 7 fundamental movement patterns, including



1. deep squat
2. hurdle step
3. lunge
4. shoulder mobility
5. leg raise
6. trunk stability push-up, and
7. rotary stability.

By asking the athlete to execute these extreme positions, any inherent weaknesses in locomotor, manipulative and stabilizing movements will inevitably be exposed. And, once the FMS has been completed, a healthcare professional can prescribe a customized program of exercises that will strengthen any apparent deficiencies. The FMS is intended to be a screening tool to identify opportunities to help healthy individuals build strength, develop symmetry, and ultimately avoid injury; it is not meant to be used on those who are recovering from an injury. The test is typically given by a physical therapist, personal trainer, athletic trainer, or chiropractor.

The SFMA is a diagnostic tool designed to measure pain and dysfunction from movement patterns in those with known musculoskeletal

Continued on page 54

Continued from page 53

pain. Using a series of full-body movements broken down by cervical, upper-extremity, and multi-segmental movement patterns, a qualified medical professional, such as a physician, physical therapist, physiotherapist, athletic trainer or chiropractor, can identify impairments that may be contributing to the pain. Because parts of the body are so interdependent, the root cause of pain is often caused by something seemingly unrelated, such as pain in the calves while running caused by a weakness in the hips. The focus of the SFMA is on the quality of the execution of each movement, which will then inform the patient's treatment plan. Remember, the SFMA is for individuals who are already experiencing pain, so the goal of this assessment is to determine the best course of action to get the athlete healthy and moving properly again.

Functional Assessments in Action

Using functional assessments, the physical therapist or athletic trainer will score athletes on how well they perform a number of specific movements and their execution as a whole. We can then take into consideration the information garnered from the test, i.e., any identified asymmetries or weaknesses, and the athlete's relative score for future activity. For example, a physical therapist would use the results of the initial test as a baseline during rehabilitation following an injury to determine when the player can return to the field. Or, an athletic trainer may use it to retrain an athlete whose body is asymmetrical and make any necessary adjustments to decrease the potential risk of injury. This testing also provides a baseline score of regular physical function, which can be used to monitor progress of strength and mobility as the athlete continues physical training. The information is extremely valuable whether the athlete is currently healthy or experiencing musculoskeletal pain.

It's important to note that a low score does not necessarily indicate that an injury is on the horizon or that the athlete will never recover, though my colleagues and I have seen a correlation between injuries and test results with athletes. Often when an athlete's performance earns a lower score, we can make the necessary adjustments and drastically reduce the risk of injury altogether. From my professional experience, athletes tend to take these results as a wake-up call highlighting the need for a dramatic change, particularly if the score of the assessment is extremely low.

There are other assessments that can be used in conjunction with the FMS and SFMA. For example, I use the single leg hop test and the tuck jump assessment when a lower extremity injury has already occurred, or to determine if an athlete is at risk of an injury occurring in the future. The single leg hop test is used primarily after an ACL tear, but may also be used for ankle or knee injuries. To execute the single leg hop test, the athlete puts all of his or her weight on one leg and then explodes in a forward jump and lands firmly on that leg. Then repeats with the alternate leg. The distance between the non-efected leg and the effected leg should be around 90%. If this is not the case, or if the athlete is unable to balance on that leg after the hop, we know that we need to work on motor power. This test is quite telling. In fact, one noted study[2] found that when performed 6 months after an ACL reconstruction, this test can indicate the athlete's likelihood of experiencing a successful outcome at one year post-surgery.

The tuck jump assessment has two variations and is most often used to determine if an athlete is at risk of an ACL injury. In the first variation, the athlete is asked to do a single tuck jump—squat, jump, bring both knees to chest, and land. The physical therapist or athletic trainer analyzes the patient's takeoff, landing, and body position in the air to determine if there is symmetry between the left and right sides. The other variation is a timed test—the athlete performs 10 tuck jumps in a row and is assessed on their form and frequency. If there is a significant pause between jumps or if the foot placement changes between jumps, an imbalance may need to be addressed. A physical therapist can then work with the athlete to retrain the muscles in segments and teach the body to perform the motions appropriately. For example, you may want to break down the components of the tuck jump, first focusing on mastering the squat before moving on to the jumping portion. To figure out what muscles may not be firing properly, I will often change the environment that the movement is being done in by adding in a level of instability or changing the plane of motion.

Limitations and Conclusions

There are many common misconceptions about the FMS and the SFMA, and the role each test can and should play in athletes' lives. As discussed, these screening and diagnostic tests have specific strengths related to lower extremity injuries, which, when used appropriately, are helpful for baseline testing and injury prevention in athletes. However, the tools themselves are not intended to serve as a stand-alone solution for avoiding injury, an alternative for a medical diagnosis, or a direct performance metric.

We recommend that athletes of all performance levels see a qualified sports medicine clinician for a full assessment and a strategic combination of professional knowledge and outcomes tools to best assess lower extremity strength and stability. While there will never be one direct answer to injury prevention, working with a qualified healthcare professional is the best route to avoiding injury, staying healthy, and becoming a better athlete. ler

Sami Ahmed, DPT, CES, SFMA, CMTPT is a physical therapist with The Centers for Advanced Orthopaedics, specializing in athletic performance.

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2. Logerstedt D, Grinden H, Lynch A, et al. Single-legged hop tests as predictors of self-reported knee function after anterior cruciate ligament reconstruction: the Delaware-Oslo ACL cohort study. Am J Sports Med. 2012;40(10):2348-2356.

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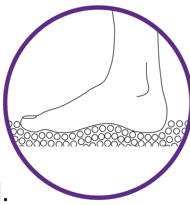

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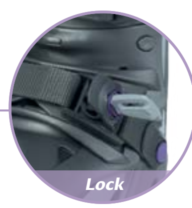

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New & Noteworthy

Noteworthy products, association news, and market updates

ETECH_RX

KLM Laboratories continues to use innovation to help footcare practitioners meet the ever-changing podiatric needs of patients with the introduction of the eTech_Rx, a new, cost-efficient custom prescription orthotic device. The eTech_Rx is a direct milled polypropylene orthotic featuring a 4-degree varus intrinsic rear foot post and a simulated leather top cover. The stiffness of the shell can be modified to meet the needs of each patient: flexible, semi-flexible, semi-rigid, or rigid. This product requires the practitioner to send a digital cast of the patient's foot to the lab using the company's secure online ordering system called eLab.

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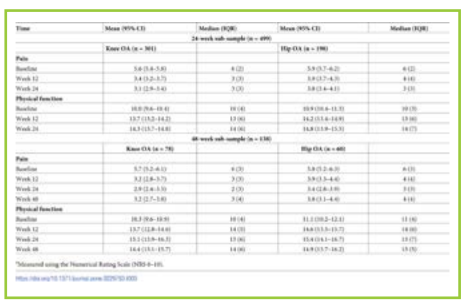
APP HELPS REDUCE OA PAIN

By performing a few simple physical exercises daily and receiving information about their disease regularly, 500 patients with osteoarthritis (OA) were able to, on average, halve their pain in 6 months—and improve their physical function. The participants in the study from Lund University, Sweden, used a newly developed mobile app to help them keep track of their activities; researchers followed the patients over a longer than typical period, in some cases for up to a year. The study is published in *PLOS ONE*.

"We expected patients to see an improvement, but these results exceeded our expectations," said researcher and physiotherapist Håkan Nero, PhD. "This demonstrates that using digital tools when treating chronic illnesses such as osteoarthritis can work very well." A mobile app is easily accessible and can be used anywhere, and it provides an alternative to physical therapy in a clinic, he said.

The study included 500 patients from all over Sweden with OA of the knee or hip, with a majority of slightly overweight women around the age of 60 (an average body mass index of 28 for those with knee OA and 27 for those with hip OA). At the beginning of the study, participants filled out a health form, something they then had to repeat every 3 months. They received 2 to 3 exercises daily, which took only 5 to 10 minutes to complete, as well as daily lessons on OA for the entire period. The exercises were designed to strengthen the muscles in the affected area.



Time	Mean (95% CI)	Median (IQR)	Mean (95% CI)	Median (IQR)
		24-week sub-sample (n = 499)		
	Knee OA (n = 301)		Hip OA (n = 198)	
Pain				
Baseline	5.6 (5.4–5.8)	6 (2)	5.9 (5.7–6.2)	6 (2)
Week 12	3.4 (3.2–3.7)	3 (3)	3.9 (3.7–4.3)	4 (4)
Week 24	3.1 (2.9–3.4)	3 (3)	3.8 (3.4–4.1)	3 (3)
Physical function				
Baseline	10.0 (9.6–10.4)	10 (4)	10.9 (10.6–11.3)	10 (5)
Week 12	13.7 (13.2–14.2)	13 (6)	14.2 (13.6–14.9)	13 (6)
Week 24	14.3 (13.7–14.8)	14 (6)	14.8 (13.9–15.3)	16 (7)
		48-week sub-sample (n = 138)		
	Knee OA (n = 78)		Hip OA (n = 60)	
Pain				
Baseline	5.7 (5.2–6.1)	6 (3)	5.8 (5.2–6.3)	6 (3)
Week 12	3.2 (2.8–3.7)	3 (3)	3.9 (3.3–4.4)	4 (4)
Week 24	2.9 (2.6–3.3)	2 (3)	3.4 (2.8–3.9)	3 (3)
Week 48	3.2 (2.7–3.8)	3 (4)	3.8 (3.1–4.4)	4 (4)
Physical function				
Baseline	10.3 (9.6–10.9)	10 (4)	11.1 (10.2–12.1)	11 (6)
Week 12	13.7 (12.8–14.6)	14 (5)	14.6 (13.5–15.7)	14 (8)
Week 24	15.1 (13.9–16.3)	15 (6)	15.4 (14.1–16.7)	15 (7)
Week 48	14.4 (13.1–15.7)	14 (6)	14.9 (13.7–16.2)	15 (5)

*Measured using the Numerical Rating Scale (NRS 0–10).

Pain and physical function at baseline and follow-up. Courtesy of *PLOS ONE*.

Each week, the patients reported their pain levels in the app, and tested their physical ability every 2 weeks. "After 6 months, the group averaged almost half the amount of pain, and their physical mobility had improved by an average of 43%," said Nero. "The results were equally good for those who continued the program for up to a year. Normally, hip osteoarthritis is more difficult to treat, but in our study, we saw no difference between knee and hip, and the same applied to gender and age."

The app is operated by the company Joint Academy, Malmö, Sweden, for which Nero is a part-time consultant.

TULI'S SO SOFT HEEL CUPS

Tuli's So Soft Heel Cups from Medi-Dyne are designed to provide relief for common ailments such as plantar fasciitis, Achilles tendonitis, shin splints, and general heel pain and discomfort. The multi-cell, multi-layer design absorbs shock and returns impact energy just like the system naturally found in feet. According to the company, this shock absorption and elevation of the heel bone provide immediate heel pain relief and assist in long-term healing. The patent-pending Tuli's So Soft Heel Cups are formulated to be lighter, softer, and more resilient than other heel cups. With the added comfort of a soft cloth heel bed and a low-profile heel backing, it is easily worn in most shoes.

Medi-Dyne
800/810-1740
medi-dyne.com

VR SHOWS PROMISE FOR EARLY DETECTION OF MS BALANCE ISSUES

People with multiple sclerosis (MS) often have a greatly increased risk of falling and injuring

Franz's Applied Biomechanics Laboratory uses VR to address issues of health, including balance problems, for people with MS. Image courtesy of UNC-Chapel Hill.

themselves even when they feel they're able to walk normally. Now a team led by scientists from The University of North Carolina (UNC) Chapel Hill School of Medicine has demonstrated what could be a relatively easy method for the early detection of such problems using virtual reality (VR). The study was recently published in *PLoS One*.

Study principal investigator Jason Franz, assistant professor in the UNC-Chapel Hill/North Carolina State Joint Department of Biomedical Engineering, and his colleagues sought to develop a test that would reveal balance and gait impairments even in people with MS who may not be aware of these problems or display them during normal walking. They employed a VR device that allows the experimental manipulation of visual perception. Their laboratory device is like a semi-circular theatre screen that study participants watch while walking on a treadmill. The VR scene depicted a hallway down which participants seemed to be walking, at the same speed that they walked on the treadmill. Sometimes side-to-side wobbles in the scene created the illusion for each participant that he or she was becoming unstable, triggering a corrective reaction that could be measured as a change in gait and foot placement. Franz's hypothesis was that the participants who had MS with balance impairments would differ clearly from non-MS participants in these corrective reactions.

The scientists tested 14 people with MS and 14 age-matched non-MS participants. They found that there was indeed a clear difference between the groups in their reactions, but this only became clear when using the VR balance challenge. Franz and his colleagues now are adapting their system for use with consumer-grade VR headsets as a routine diagnostic tool to be used in neurologists' clinics to detect balance impairments that would otherwise go unrecognized. They also hope to develop the VR system as a physical therapy tool to help MS patients improve their balance and thus reduce the risk of falls.

MULTIMOTION HIP ABDUCTION SYSTEM

The MultiMotion Hip Abduction System from Allard is a nighttime treatment for correctable pediatric hip contractures. The system consists of two components: the MultiMotion Corrective Joint and the Abduction Bars. These two components are mounted to a custom-fabricated orthosis, which places the child's legs in an optimal position and stabilizes the hip joint. The system works by stretching the adductors gradually to allow for better joint mobilization. The hip abduction system has adjustable flexion and extension stops: small 14-degree intervals, regular 12-degree intervals. The MultiMotion Hip Abduction System is designed to manage spastic diplegia, spastic tetraplegia, spastic triplegia, or congenital subluxation of the hip joint.

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ATHLETIC SHOE AFO

Kinetic Research has taken all the proprietary features of its Noodle AFO and enhanced the design and functionality to create the customizable Nano AFO and Nano Anterior AFO. With trimmable footplates, the AFOs fit the contours needed for comfort and use in athletic shoes. The dynamic posterior Nano is set at a neutral position while the Nano Anterior is set in slight plantarflexion for a true floor reaction effect; both accommodate simple foot drop, prevent foot slap, and dampen heel strike. These durable, lightweight AFOs incorporate the company's patented dynamic energy-returning strut. The Nano is designed to be superior for runners with foot drop and those who tire easily because of muscle loss or lack of flexion.

Kinetic Research
800/919-3668
kineticresearch.com

WILLOWWOOD WELCOMES NEW CFO

Prosthetic solution provider WillowWood, Mount Sterling, OH, announced that Craig Higgins is the company's new chief financial officer. His focus will be on financial planning, operating budgets, and decision support analysis to guide the leadership team with investments and capital expenditures as well as implementing systems and processes to facilitate the company's growth as the company scales.

"Without a doubt, Craig was the right choice," said Mahesh Mansukhani, WillowWood's CEO. "He's not only the best fit, but he's a treasure trove of experience and will further our initiatives to drive performance, growth, and overall success."

UPCYCLED COTTON 5-TOE SOCK COLLECTION

Injinji, innovator of the patented 5-toe-sleeve Performance Toesock, announced the launch of its Everyday Upcycled collection. The new, limited-edition collection incorporates a sustainable design and an upcycled fabric blend. The Injinji Upcycled Cotton collection offers an Everyday Lightweight Crew Upcycled Cotton style and an Everyday Lightweight Hidden Upcycled Cotton style, each available in 2 colors. The hidden sock style has a silicone non-slip heel grip that helps to keep socks in place without slipping and bunching inside the shoe. These socks are constructed of a fiber blend called Recover Blue, consisting of upcycled cotton fibers and recycled polyester that is sourced from post-consumer bottles. The resulting ultra-soft recycled fiber is lightweight and keeps feet comfortable, while the low-impact manufacturing process reduces carbon emissions, saves energy, and reduces water and land use.

Injinji
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FOLDABLE, PORTABLE, AFFORDABLE THERAPY TABLE

New from Mastercare, the Swedish Backcare System, is the Mini-Mini therapy table. The foldable, portable, and affordable table is recommended by specialists for youth athletes and for traveling when daily traction is needed. It can also be used at home as adjunctive therapy for the patient. The table uses gravity traction along with a system of therapeutic exercises for the relief, rehabilitation, and prevention of knee, hip, chronic back, neck, and shoulder problems. Due to its moving backrest, the table allows therapeutic exercises in 15-degree inclinations. By not incorporating a footplate into the Mini-Mini design, it allows both dorsiflexion and plantarflexion movements to avoid periostitis. The concept of Mastercare therapy is to provide for unloading of the discs, thereby reducing pressure and discomfort. The Mini-Mini is designed for users up to 220 lb. and 6'3" tall.

Mastercare
mastercare.se

SUBIOMED APPOINTS NEW CHAIRMAN OF THE BOARD

SubioMed, Bloomington, MN, the inventor/developer of Suspension Biomechanics technology addressing elements of gait and balance, announced that the company's chief executive officer and co-founder, Patrick Kullman, has also been appointed chairman of its board. Kullmann previously served in leadership positions, most recently at Medovex, as well as at Johnson & Johnson, Boston Scientific, Medtronic, and multiple startup medical technology (Medtech) companies. Kullman wrote *The Inventors Guide for Medical Technology* and is a Fox Business News network contributor.

SubioMed also welcomed Gary Peterson and Michael McBrayer as board members. Peterson has over 45 years of experience in the medical device, health services, and finance business. McBrayer, senior vice president of DJO Global (DJO), started his career in 1986 in the medical device business and progressed upward through sales and business development roles at DJO. He has been instrumental in product development projects and programs and has been a significant contributor in various acquisitions and business changes.

ÖSSUR ACQUIRES SCANNING, DESIGN TECHNOLOGY

Össur, Foothill Ranch, CA, has purchased the rights to proprietary design and visualization software used in the shape capture, design, and manufacture of orthoses and prostheses (O&P) from Standard Cyborg, San Francisco, CA, a privately held startup company that develops computer vision tools. This computer-aided design technology will offer efficiencies in socket fabrication by allowing O&P providers to use a tablet to capture accurate, 3D images and make modifications of their patient's residual limb. Financial details of the transaction were not disclosed.

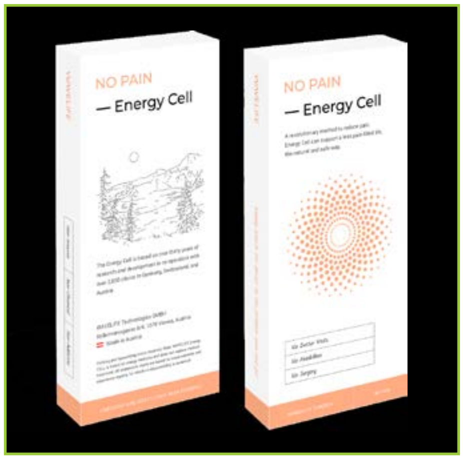
SPIRALUP TCL ALLOGRAFT SYSTEM

Arthrosurface has launched its SpiralUp TCL Allograft System, which is designed for adult and adolescent patients suffering from talocalcaneal instability, peritalar subluxation, and other injuries resulting in instability in the subtalar joint. The conditions usually

present as back, knee, hip, arch, and heel pain; poor posture; nerve entrapments; and tarsal tunnel syndrome. The system supplements the talocalcaneal ligament, functioning as a dense, strong, and flexible connective tissue layer intended to improve function of the foot as well as conditions along the musculoskeletal chain. It is inserted across 80–90% of the sinus tarsi where it is able to stabilize the anterior, middle, and posterior of the subtalar joint more effectively than existing metal implants.

Arthrosurface
508/520-3003
arthrosurface.com

WEARABLE, ALL-NATURAL APPLICATION FOR REDUCING CHRONIC PAIN

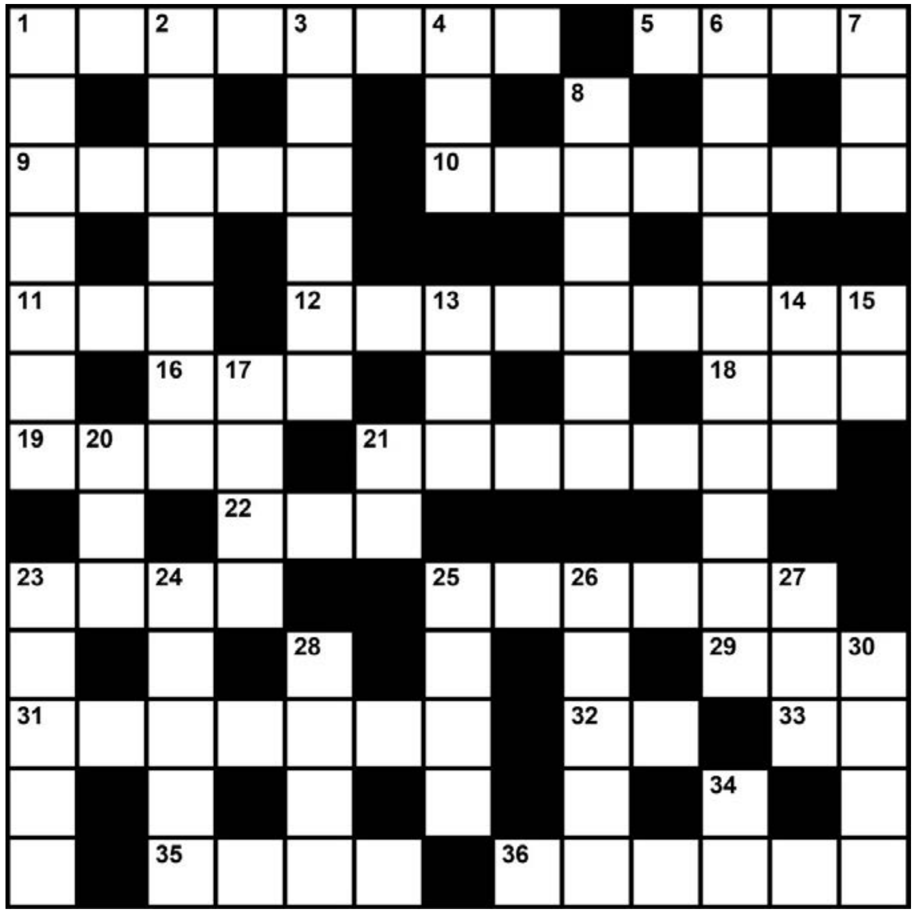


WaveLife Energy Cell is a new, wearable, and all-natural application for reducing chronic pain. It uses an advanced form of frequency therapy, which clinical studies have shown to be effective. The patented electromagnetic frequency can retain and emit Vital Fields—a form of frequency therapy that introduces a subtle electromagnetic field into an area of damaged tissue where an injury or strain took place, and where pain is experienced. A composite cell material stores and emits the Vital Field therapy for up to 6 months. This chemical-free, wearable silicone patch can be placed on your body with a non-irritating adhesive material. The WaveLife Energy Cell influences cell activity in the body once it is placed on the skin by enhancing cell communication and expediting cell regeneration. It can be worn 24 hours per day, even while bathing, and no side effects have been reported by users.

WaveLife Technologies
wavelife.com

How Well Did You Read This Issue?

Test your knowledge of information from this issue of *Lower Extremity Review* and the world in general with our crossword puzzle feature. The answer box can be found online at lermagazine.com.



ACROSS

1 Condition where there's an ever-present ankle sprain, goes with 6 down
5 Foot motion
9 Crack
10 Correctly positioned
11 Function
12 Peroneal longus tendon attaches to this tarsal bone
16 GPS guidance, abbr.
18 Agree quietly
19 Reduce stress or pain
21 Slender projection of bone
22 Pouch-like structure
23 The S in IASTM, a type of tissue
25 _____ muscles, not long
29 International cry for help
31 Extending to the side
32 6-point score, abbr.
33 School exercise class, for short
35 Exercise regimen from India
36 Sheath of connective tissue

DOWN

1 Arrangement of the body and its limbs
2 Massage tools being used by consumers
3 Observe
4 Largest medical organization, for short
6 See 1 across
7 Protective shoe addition
8 Shinbone
13 Volleyball obstacle
14 Long metal implant
15 Doctor, abbr.
17 Assessment
20 Earlier
21 Southern state, abbrev.
23 Anything that remedies, heals, or soothes
24 Kind of tissue
25 Rounded anatomical body, as in ____ of the foot
26 Additional
27 Soak (up)
28 Pull along with difficulty
30 Inoculation fluids
34 Dosage measure, abbr.

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

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