

# ler

**LOWER EXTREMITY REVIEW**

April 21 / volume 13 / number 4

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Six LER experts weigh in on the use of gait analysis in some specific circumstances.

By Janice T. Radak, Editor

Cover photography courtesy of ProtoKinetics

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In this new regular column, prosthetist Terrell Tate traces his journey into the digital realm.

By Terrell S. Tate, BOCPCO



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By Paul J. Betschart, DPM



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#### 27 GAIT AND BALANCE ACADEMY HOW DO WE USE GAIT ANALYSIS TO MEASURE WALKING CONSISTENCY?



Have you ever asked: why do we measure and analyze gait? Overall, the answers will revolve around the same ideas: to gauge the functional status of a person; to follow-up the natural history of a disease; to determine immediate or long-term treatment requirement and effects. But how do we do it?

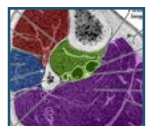


By Arnaud Gouelle, PhD, and Patrick Roscher, MS

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Chronic compartment syndrome is an often-overlooked diagnosis in patients who are athletically inclined. With an average 22-month delay in diagnosis, suspicions need to be elevated sooner.



By Hayley Iosue, DPM, Joseph Albright, DPM, and Mark Mendezsoon, DPM

#### 45 FALLS IN PEOPLE WITH MULTIPLE SCLEROSIS, PART II: RISK IDENTIFICATION, INTERVENTION, AND FUTURE DIRECTIONS

With the increasing trend in falls in people with multiple sclerosis, these authors sought to summarize the current data examining falls in people with MS and identify gaps in knowledge, challenges, and potential ways forward.



By Susan Coote, PhD; Laura Comber, PhD; Gillian Quinn, PhD; Carme Santoyo-Medina, MSc; Alon Kalron, PhD, PT; Hilary Gunn, PhD

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### LOWER EXTREMITY REVIEW

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

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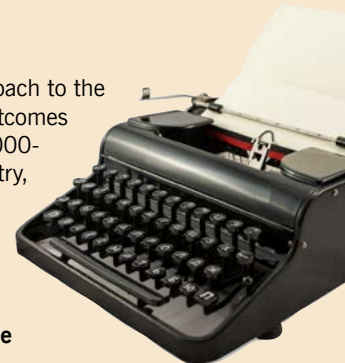
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LER encourages a collaborative multidisciplinary clinical approach to the care of the lower extremity with an emphasis on functional outcomes using evidence-based medicine. We welcome manuscripts (1000-2000 words) that cross the clinical spectrum,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

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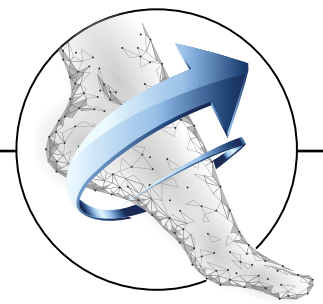


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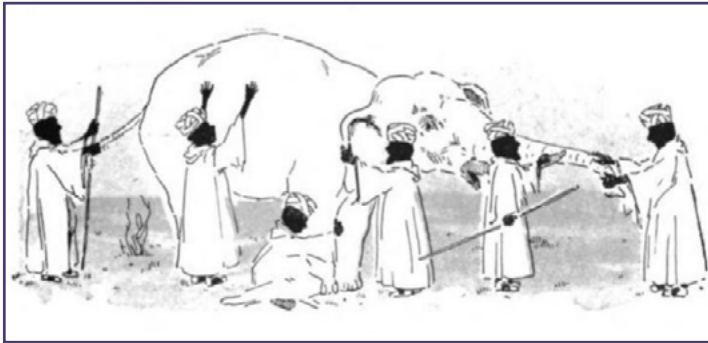
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## Of Gait Analyses and Elephants



While researching the history of gait analysis to prepare for this issue, the parable of the blind men and the elephant kept coming to mind. The ancient story is of a group of blind men who have never seen an elephant. On encountering a live elephant, they each touch a different part of the large mammal and come away thinking they know what it is. They then describe the elephant based on their own experience and find all their descriptions differ. The moral of the

story points to the tendency of humans to claim they know things based solely on their own experience, not recognizing that others may have completely different experiences. Could this be the case with gait analysis and the various subspecialties who treat the lower extremity? Is gait analysis being used to its fullest extent?

With this issue, *LER* is pleased to open an ongoing partnership with the Gait and Balance Academy to provide an in-depth look at all things gait analysis. The introduction to this partnership, “How Do We Use Gait Analysis to Measure Walking Consistency,” is written by Arnaud Gouelle, PhD, and Patrick Roscher, MS, from ProtoKinetics; the article begins on page 27. We look forward to your feedback.

But first, to broaden the narrative, a sampling of perspectives on how gait analysis is used in some specific circumstances.

– **Janice T. Radak, Editor**

## ...In Orthotics and Prosthetics


Normal human locomotion requires a complex interaction of anatomical segments, moving synchronously in relation to each other and the body's center of mass and incorporating dynamic propulsion from point “A” to point “B.” Because of its complexity, bipedal locomotion, aka gait, has been extensively researched and utilized in the diagnosis and treatment of complex orthopedic conditions. Over the past half century, human gait has been dissected and studied, initially using still images-then videography until the evolution of computerized motion analysis. Gait labs have proliferated as the understanding of the kinetics/kinematics of walking have been illuminated by sophisticated computer software programs, 3D videography, and force plate data. Numerous institutions have access to state-of-the-art gait labs for pre-op diagnosis and post-op quantification of outcomes. However, despite the growing subscription to the value of computerized motion analysis, these resources are few and far between in relation to the practicing orthotist/prosthetist. So, what is the true impact of gait analysis on the average O&P professional who has minimal

affiliation with a major medical/academic institution? The answer may be much more linear than one thinks.

Gait analysis does not necessarily have to involve a fully outfitted motion lab. It can be as pedestrian as observing/recording a 10-meter walk test in a specific orthotic design. Or it can be the use of one of the several user friendly/affordable gait assessment tools on the market today (GaitRite, Motion Monitor, etc.) or recently available phone apps that record sensitive gait data directly on your smart phone. The most critical implication that the gait analysis technology has had on orthotics/prosthetics today is the heightened awareness of the value of quantitative and qualitative data on evidence-based practice. The accumulation and summative reporting of gait data as a result of specific O&P interventions has led to a greater number of scientific publications than ever before. Today's practitioner must be acutely cognizant of the impact of their interventions on key aspects of their patient's functional performance with functional gait often the ultimate goal. Even if the “analysis” is purely observational in nature,

*Continued on page 10*

the fundamental understanding of normal human locomotion, identification of pathologic deviations and the correlation between what we do and how it effects complex joint kinetics/kinematics/energy consumption and balance demonstrates the profound impact that the study of human motion has had on orthotics/prosthetics. Everyday we make clinical decisions based on our gait analysis. Component selection, design features, alignment, and material

selection are all contributing factors to the optimal outcomes we strive for. The relationship is inextricable and profound. 

*Robert S. Lin, MEd, CPO, FAAOP is Managing Partner at Biometrics INC in Hartford, CT. In practice for over 40 years, he has lectured extensively on gait, biomechanics, and pediatric orthotics. Lin also serves on the LER Editorial Advisory Board.*

---

## ...In Running

Weekly I am posed the question from patients, physicians, therapists, and coaches as to whether I perform “gait analysis.” The simple answer is YES, as I am keenly interested in the unique movement patterns of all of my patients. As a sports medicine clinician, I need to understand an athlete’s asymmetries and weaknesses that may lead to pathologies. This is particularly true for runners.

The part that becomes confusing is what the asker’s expectations are of what this term means and how this process is carried out. The common practice of having a runner hop on a treadmill and watching them from behind is not gait analysis and should never be touted as such. Understanding the runner’s movement patterns through an organized approach is the only way to help them achieve metabolic efficiency and decrease the risk of injury.

By definition, gait analysis is the systematic study of human motion, using the eye and brain of the observer. This may be augmented by instrumentation that may help measure the movements and mechanics of the body.


The process begins with GREAT communication. A thorough history will help the physician understand what the athlete’s goals are. Once the goals are established, the clinician must listen to the patient’s story to understand where they have come from and why they are seeking your expertise.

To truly understand a runner’s gait, a simple dynamic assessment is critical. Asking the runner to perform simple tasks

of single leg balance and squats are key to uncovering areas of weakness and asymmetries. Typically, these inequalities are quite glaring and the source is usually higher up the kinetic chain from where the pathology is felt. The great aspect of this is that the runner can actually feel and see their deficit if we are utilizing a mirror or video recording.

While not always realistic, the best way to analyze a runner’s gait is to observe them when they do not know they are being watched. Sometimes even catching their movement patterns when walking into the clinic can be quite informative.

Finally, it is imperative to understand how the runner uses stability, power, and strength when running to analyze their form. The best way to do this is to watch them run from a multitude of perspectives outside as opposed to on a treadmill. Motorized treadmill running takes quite a bit of acclimation and may not truly assess the individual’s form.

The goal of gait analysis is to tie in all of the above information in order to document and quantify objectively normal gait, functional deficits, and put forth a therapeutic plan. 

*Robert M. Conenello, DPM, is a is the founder and sole proprietor of Orangetown Podiatry, a New York metropolitan-based practice, whose emphasis is on prevention and rehabilitation of lower extremity pathologies. He is the Clinical Director of the Special Olympics New Jersey Healthy Athletes division and the Past President of the American Academy of Podiatric Sports Medicine. Conenello also serves on the LER Editorial Advisory Board.*

---

## ...In Falls Prevention

Walking is a complex motor task generally performed automatically by healthy adults. Yet, by the older adult, walking is often no longer performed automatically. Older adults require more attention for motor control while walking than younger adults. Falls, often with

serious consequences, can be the result. Gait impairments are one of the biggest risk factors for falls. Several studies have identified changes in certain gait parameters as independent predictors of

Continued on page 13

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fall risk. Such gait changes are often too discrete to be detected by visual observation alone. For proper analysis of gait disorders in the older adult, research shows the use of a pressure mapping system allows a clinician to obtain quantitative data necessary for accurate evaluation of the individual, which leads to appropriate clinical pathways. Multiple companies offer pressure mapping technology for gait analysis. Utilizing such technology for dynamic postural control in the older adult, a key area should be examined, the sensory system. Sensory systems in older adults have been implicated in their reduced ability to adapt to changes in the environment and maintain balance; the visual system is particularly important in maintaining postural stability. There are distinct changes in gait associated with the visual system, such as slower gait and increased gait variability. Exposure to visual perturbations

and manipulations emphasizes these changes in gait. Increased gait variability, specifically with mediolateral perturbations, poses a particular challenge for older adults, as it has been linked to falls. Thus, treatment to improve balance along with gait in the older adult is imperative to overall positive outcomes and continued independent living. 


*Philip Stotter, veteran clinical exercise physiologist turned inventor/business developer, is the Visionary and Founder behind The Stotter Clinic, Moflex, AA360, and others. These days, Philip focuses on ground mechanics and how to use technology to augment the test/treat or test/train intervention process. His most recent venture is as Director of Sports Science for V1 Sports. Based in Cleveland, OH, he is the newest member of the LER Editorial Advisory Board.*

## ...In Footwear

Gait analysis and the influence of various types of footwear is wide and varied, each of which integrate components of kinematics, kinetics, electromyography and efficiency measures. In more recent times, gait analysis has been supported by patient-/participant-centered outcomes that feature aspects of comfort, perception of footwear and pain, enabling a comprehensive overview from a multi-disciplinary and patient-centered educational perspective. On a daily basis, footwear for many of us is an attire not just for fashion but for its rudimentary properties that include protection, stability, cushioning, fitting, and flexibility. When footwear is worn, it provides the interface between the foot and the supporting surface and whilst this can offer functional support and protection to the foot, it can reduce tactile feedback compromising postural stability and balance. Such features are made worse, with high-heeled footwear and thicker outer soles, increasing the risk of falls, particularly in older individuals who are advised to wear slip resistant soles and low heels.

Running footwear and analysis is perhaps one of the leading areas of research with studies exploring the impact of cushioned and supportive to minimal footwear design on the impact of running economy, asymmetry, spatial and temporal parameters, footstrike, impact forces, limb alignment and muscle function. Compared to conventional (cushioned/supportive) running footwear, minimalist footwear is characterized as having a lower profile and heel-to-toe drop, increased flexibility of the sole and a smaller mass.

These features are considered to provide minimal interference to the natural motion of the foot with studies reporting a forefoot or midfoot strike and reduction of impact forces, which for some individuals minimizes the risk of injury.

The notion of minimal footwear has translated to everyday footwear – but has received little attention in the literature, especially when stability and the functional effects are considered for older adults and the potential risk of related falls. In a recent study, Cudejko et al employed a repeated-measures design of 13 types of footwear conditions in 22 adults (mean age 55.4 years, SD 7.8) that ranged from barefoot, conventional, to minimal footwear. These authors found that postural and dynamic stability (one of which included the center of pressure) improved with minimal footwear, even when compared to barefoot, features of which support similar findings of Peterson et al. Cudejko et al also noted that the participant's perception on choice of design of footwear was one that disfavored a higher ankle collar and split toe, each of which were considered unfashionable. Whilst further research is needed, the future design of minimal footwear may be able to decrease the risk of poor stability and reduce the risk in falls in older adults, as well as enhancing patient compliance. 


*Sarah Curran, PhD, is Professor of Podiatric Medicine and Rehabilitation at the School of Sport and Health Sciences, Cardiff Metropolitan University in the United Kingdom. She is a long-standing member of the LER Editorial Advisory Board.*

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## ...In the Assessment of Neuropathy

Peripheral Neuropathy (PN) is a prevalent condition among patients with diabetes. The utilization of gait analysis is a vital tool in assessing the physiological manifestations of PN. For example, Suda et al utilized the measurement of toe clearance to assess how PN predisposes patients to falling and tripping. Huang et al utilized the measurement of toe elevation, stride time, and stance time to assess how PN affects a patient's gait while study participants stepped over obstacles. Dingwell et al utilized kinematic data to characterize walking speeds and gait variability in PN patients. These studies have aided in our understanding of PN and its consequences on gait mechanics.

Currently, there are two overarching theories on these effects. One theory is that patients with PN move more conservatively to maintain their balance and gait, resulting in a person walking "stiffer" and more "robotic." In this scenario, there are compensatory mechanics that stabilize gait. The opposing theory is that patients have more erratic or variable gait due to the lack of

proprioceptive feedback. Utilizing gait analysis techniques such as center of pressure measurements from sequential steps in patients with PN can characterize gait patterns to assess which theoretical construct is present in these patient groups. Insights gained from sophisticated algorithms (such as wavelet analyses, Lyapunov exponents, or maximum Floquet multipliers) coupled with new wearable sensors, will almost certainly increase our understanding of the systemic effects of neuropathy and potentially provide researchers and clinicians with new tools to treat gait abnormalities caused by diabetes. 


*Jessi K. Martin is a Master's degree student at Cleveland State University in biomedical engineering. Brian L. Davis, PhD, is Associate Dean of the College of Engineering and Professor of Biomedical Engineering at Cleveland State University, Cleveland, OH, where he focuses on the development of rehabilitation technology and instrumentation for assessing a patient's risk for diabetic foot ulceration.*

---

## ...In Return-to-Play Decisions

Gait analysis is central to the return-to-play decision-making process for nearly all athletes recovering from lower extremity injuries. Because athletes in different sports have varying functional demands among running, jumping (and landing), and agility, a clinician's gait analysis should be tailored to assess the tasks specific to an individual athlete's demands. Gait analyses should include both subjective and objective assessments of an athlete's gait. Observation of athletes can be performed in controlled situations such as treadmill running as well as in sport-specific contexts (eg, on the practice field or court). The athlete should also be asked about their perception of recovery and confidence, or lack thereof, when performing challenging maneuvers. Objective measurement approaches can range from low tech (eg, smartphone apps involving basic video analysis) to high tech (eg, 3-D motion analysis and instrumented treadmills). The continuing evolution of wearable biomechanical sensors provides another option for objectively assessing athlete's gait in sport-specific contexts.

Key parameters during gait evaluation should include whether the athlete's movement patterns involve any guarding

or compensations that may indicate an attempt to protect the recovering injury. While perfect limb-to-limb symmetry in objective gait measures is rarely realistic, differences of greater than 10% to 15% between injured and uninjured limbs should be concerning. I subscribe to the mantra of "you can't manage it if you don't measure it". Thus, I advocate for documentation of both subjective and objective gait analyses so key outcome measures can be tracked as an athlete moves through a return-to-play progression. I also think that a single gait analysis should not be the only benchmark on which a return-to-play decision is made. Instead, the determination of an athlete's readiness to return-to-play should be based on a series of decisions that are made throughout an athlete's recovery from lower extremity injury. Gait analysis, in multiple forms, should be part of those decisions throughout the recovery and rehabilitation process. 

*Jay Hertel, PhD, ATC, is Chair of the Department of Kinesiology and Joe Gieck Professor in Sports Medicine at the University of Virginia in Charlottesville, VA. Hertel also serves as Editor-in-Chief of the Journal of Athletic Training.*



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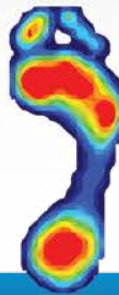
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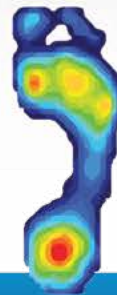
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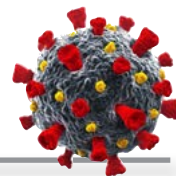
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## Most COVID-19 Hospitalizations Due to 4 Conditions

- A study estimated that nearly two-thirds of COVID-19 hospitalizations in the U.S. could be attributed to obesity, diabetes, hypertension, and heart failure.
- The findings give insight into how underlying conditions contribute to hospitalizations during the pandemic.

Studies show that certain common medical conditions put people at higher risk for severe illness from COVID-19: 2 metabolic disorders – type 2 diabetes and obesity; and 2 heart conditions – hypertension and heart failure. People with these 4 conditions are more likely to be hospitalized with COVID-19.

To better understand how these conditions affect hospitalizations, a research team led by doctoral student Meghan O'Hearn and Dariush Mozaffarian, MD, DrPH, of Tufts University, developed a statistical model. They incorporated data on the association of these 4 underlying conditions with COVID-19 hospitalizations in the U.S. They also included national data on COVID-19 hospitalizations and prevalence of the conditions by age, sex, and race/ethnicity.

Based on this data, the model calculated the percentage of COVID-19 hospitalizations that could have been prevented without these 4 underlying conditions. Results were published in the *Journal of the American Heart Association* in February 2021.

The researchers estimated that more than 900,000 COVID-19 hospitalizations occurred through November 2020. Based on their model, 30% of these hospitalizations were attributable to obesity, 26% to hypertension, 21% to diabetes, and 12% to heart failure. These people would still have been infected with COVID-19, but likely would not have been sick enough to need hospitalization.

The model also estimated hospitalizations due to different combinations of these comorbidities. The numbers weren't simply additive. In total, 64% of the hospitalizations might have been prevented if not for the 4 conditions.

The model suggested that COVID-19 hospitalizations due to these conditions varied by age. Older adults with diabetes, heart failure, or hypertension were more likely to be hospitalized than younger people with the same condition. **However, obesity affected COVID-19 hospitalization risk similarly across all age groups.**

Race/ethnicity also resulted in disparities in COVID-19 hospitalizations due to these conditions. Black adults had the highest proportion of hospitalizations attributable to all 4 conditions at any age. Other studies show that COVID-19 deaths have disproportionately affected Black and other minority communities.

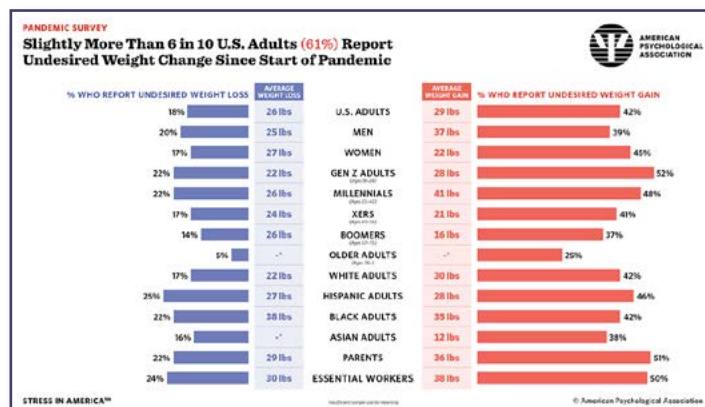
This research further highlights the burden of heart and metabolic diseases in the U.S. Almost 3 in 4 U.S. adults is overweight or obese. Near-

ly half of people living in U.S. have prediabetes or diabetes.

All of the conditions examined in the study have been shown to impair the body's immune response. This may be one reason COVID-19 causes more harm in people with these underlying conditions. Improving heart and metabolic health may help reduce hospitalizations from COVID-19. [\(ler\)](#)

**Source:** O'Hearn M, Liu J, Cudhea F, Micha R, Mozaffarian D. Coronavirus disease 2019 hospitalizations attributable to cardiometabolic conditions in the United States: a comparative risk assessment analysis. *J Am Heart Assoc.* 2021(5):e019259. doi: 10.1161/JAHA.120.019259.

## Coping With Pandemic Stress: Unhealthy Weight Gains, Increased Drinking, Poor Sleep



With vaccine availability leading to a potential turning point in the global COVID-19 pandemic, the U.S. health crisis is far from over. One year after COVID-19 was declared a global pandemic, many adults report undesired changes to their weight, increased drinking, and other negative behavior changes that may be related to an inability to cope with prolonged stress, according to the American Psychological Association's latest Stress in America poll.

APA's survey of U.S. adults, conducted in late February 2021 by The Harris Poll, shows that a majority of adults (61%) experienced undesired weight changes – weight gain or loss – since the pandemic started, with 42% reporting they gained more weight than they intended. Of those, they gained an average of 29 pounds (the median amount gained was 15 pounds) and 10% said they gained more than 50 pounds. Such changes come with significant health risks, including higher vulnerability to serious illness from the coronavirus. For the 18% of Americans who said they lost more weight than they wanted to, the average amount of weight lost was 26 pounds (median amount lost was 12 pounds). Adults also reported

Continued on page 18

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Continued from page 17

unwanted changes in sleep and increased alcohol consumption. Two in 3 (67%) said they have been sleeping more or less than desired since the pandemic started. Nearly 1 in 4 adults (23%) reported drinking more alcohol to cope with their stress.

“We’ve been concerned throughout this pandemic about the level of prolonged stress, exacerbated by the grief, trauma, and isolation that Americans are experiencing. This survey reveals a secondary crisis that is likely to have persistent, serious mental and physical health consequences for years to come,” said Arthur C. Evans Jr, PhD, APA’s chief executive officer. “Health and policy leaders must come together quickly to provide additional behavioral health supports as part of any national recovery plan.”

The pandemic has taken a particularly heavy toll on parents of children under 18. While slightly more than 3 in 10 adults (31%) reported their mental health has worsened compared with before the pandemic, nearly half of mothers who still have children home for remote learning (47%) reported their mental health has worsened; 30% of fathers who still have children home said the same. Parents were more likely than those without children to have received treatment from a mental health professional (32% vs. 12%) and to have been diagnosed with a mental health disorder since the coronavirus pandemic began (24% vs. 9%). More than half of fathers (55%) reported gaining weight, and nearly half (48%) said they are drinking more alcohol to cope with stress.


The majority of essential workers (54%), such as healthcare workers and people who work in law enforcement, said they have relied on a lot of unhealthy habits to get through the pandemic. Nearly 3 in 10 (29%) said their mental health has worsened, while 3 in 4 (75%) said they could have used more emotional support than they received since the pandemic began. Essential workers were more than twice as likely as adults who are not essential workers to have received treatment from a mental health professional (34% vs. 12%) and to have been diagnosed with a mental health disorder since the coronavirus pandemic started (25% vs. 9%).

Further, people of color reported unintended physical changes during the pandemic. Hispanic adults were most likely to report undesired changes to sleep (78% Hispanic vs. 76% Black, 63% white, and 61% Asian), physical activity levels (87% Hispanic vs. 84% Black, 81% Asian, and 79% white) and weight (71% Hispanic vs. 64% Black, 58% white, and 54% Asian) since the pandemic began. Black Americans were most likely to report feelings of concern about the future. More than half said they do not feel comfortable going back to living life like they used to before the pandemic (54% Black vs. 48% Hispanic, 45% Asian, and 44% white) and that they feel uneasy about adjusting to in-person interaction once the pandemic ends (57% Black vs. 51% Asian, 50% Hispanic, and 47% white).

“It’s clear that the pandemic is continuing to have a disproportionate effect on certain groups,” said APA President Jennifer Kelly, PhD. “We must do more to support communities of color, essential workers, and parents as they continue to cope with the demands of the pandemic and start to show the physical consequences of prolonged stress.”

Overall, Americans are hesitant about the future, regardless of vaccination status. Nearly half of respondents (49%) said they feel uneasy about adjusting to in-person interaction once the pandemic ends. Adults

who received a COVID-19 vaccine were just as likely as those who had not received a vaccine to say this (48% vs. 49%, respectively).

More information about the findings including the full report are available at the Stress in America™ Press Room at [www.apa.org](http://www.apa.org). 

## COVID-19-related Death in Rheumatic and Musculoskeletal Diseases (RMDs)

Researchers from the COVID-19 Global Rheumatology Alliance studied 3,729 people with RMDs and COVID-19.



- In common with the general population, older age was more closely linked to COVID-19 related death
  - Out of those who died, 69% were over the age of 65
  - There was a higher risk for death for men compared to women
- Most RMD medications were not associated with COVID-19 death
  - People with RMDs should continue taking their medication unless told otherwise by their rheumatologist or other healthcare professionals managing their care
- People with lower RMD disease activity or in remission were less likely to die from COVID-19 compared with those with higher disease activity, highlighting the importance of adequate disease control
- 3 or more comorbidities were also more common in people who died from COVID-19
  - 21% of those studied had 3 or more comorbidities
  - 43% of those studied, who died, had 3 or more comorbidities
  - Hypertension (35%), chronic lung disease (19%), obesity (BMI ≥30, 16%), diabetes 14%, other CVD (12%), and CKD (7%) were the most relevant comorbidities
- People with RMDs under certain medications may have a higher risk of severe COVID-19 disease
  - Caution may be required with rituximab, some immunosuppressants, and possibly sulfasalazine
    - Although, disease severity and comorbidities may have also contributed to these reported associations




*Source: Strangfeld A, Schäfer M, Gianfrancesco MA, et al. Factors associated with COVID-19-related death in people with rheumatic diseases: results from the COVID-19 Global Rheumatology Alliance physician-reported registry. Ann Rheum Dis. 27 January 2021. doi: 10.1136/annrheum-dis-2020-219498.*

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## Dynamic AFO Reduces Pain, Improves Function




- Conservative treatments should be considered before pharmaceuticals and surgery.
- A new brace treatment was used in populations symptomatic with foot and ankle pain.
- The bracing treatment offloaded underfoot forces during level and stair walking.
- Pain and function scores were largely improved in most patients with brace wear.

Over 2 million Americans visit the doctor each year for foot and ankle pain stemming from a degenerative condition or injury. Ankle-foot orthoses can effectively manage symptoms, but traditional designs have limitations. This study investigated the acute impact of a novel “dynamic ankle-foot orthosis” (“orthosis”) in populations with mechanical pain (from motion or weight-bearing).

**Methodology:** With and without the brace, 25 participants performed standing, over-ground level walking, treadmill level walking, stair ascent, stair descent, single leg hold, squat, and sitting. Instrumented insoles captured in-shoe vertical forces and a visual analog scale was used to assess pain levels during each activity. Subsequently, the self-perceived impact of the orthosis on the patient’s symptoms and function was ranked on a scale from –10 (most worsened) to +10 (most improved).

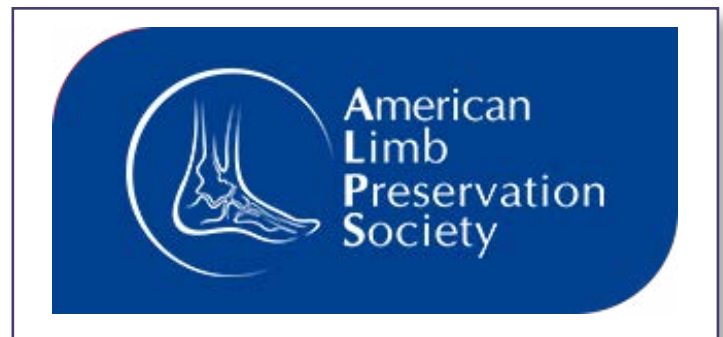
**Findings:** Peak in-shoe force was reduced during level and stair walking ( $P < 0.05$ ). Average perceived pain was 1.2 to 1.6 points lower in the orthosis than the unbraced control for the active tasks. The majority of participants ( $n = 19$ ) reported that the brace improved their symptoms, while a smaller group ( $n = 5$ ) reported that the brace did not affect their symptoms, although average function scores were improved for both groups (+2.4 to +4.5). The group of individuals with

improved symptoms included cases of osteoarthritis, tendon dysfunction, chronic pain, sprains, and nerve disorders.

**Takeaway:** The orthosis effectively improved pain symptoms and improved the ability of impaired individuals to complete functional activities of daily living such as level walking and stair walking. 

**Source:** Chung CL, Paquette MR, DiAngelo DJ. Impact of a dynamic ankle orthosis on acute pain and function in patients with mechanical foot and ankle pain. *Clin Biomech.* 2021;83:10528. <https://doi.org/10.1016/j.clinbiomech.2021.105281>. Used with permission.

## Introducing the American Limb Preservation Society




*Every 20 seconds, somewhere around the world, someone loses their leg because of diabetes.*

A commentary in the March issue of *Foot & Ankle Surgery: Techniques, Reports & Cases*, a new journal from the American College of Foot and Ankle Surgeons, introduced the American Limb Preservation Society (ALPS) with the proverb: “If you want to go fast, go alone; if you want to go far, go together.”

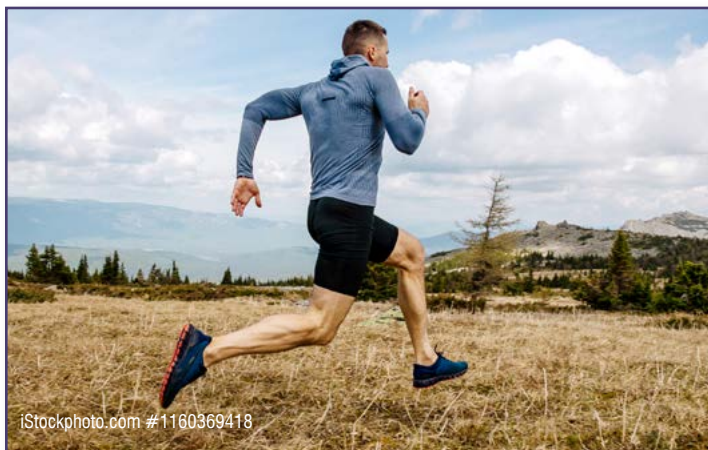
The new organization’s goal is to eliminate preventable amputations over the next generation via improved collaborative care. The group seeks to serve as an interdisciplinary bridge between patients and specialties in medicine, surgery, nursing, physical therapy, engineering, and science to foster better care of the high-risk lower extremity. The already established DFCon meeting (to be held Oct. 21-23, 2021, both in San Francisco, CA, and virtually) has been adopted as the group’s annual meeting.

Founders who signed the commentary include Ryan T. Crews, Briand D. Lepow, Joseph L. Mills Sr., John S. Steinberg, Stephanie C. Wu, and David G. Armstrong (a member of LER’s Editorial Advisory Board).

They are seeking new members. Learn more at [www.limbpreservationsociety.org](http://www.limbpreservationsociety.org). 

*Continued on page 22*

## Motion-Control Shoes Reduce Pronation-Related Pathologies



Runners frequently sustain injuries. Increased and poorly timed foot pronation during the running gait cycle and movements that contribute to foot pronation (eversion, abduction, and dorsiflexion) have frequently been cited as risk factors for exercise-related lower-leg pain, medial tibial stress syndrome, stress fractures of the tibia, Achilles tendinopathy, plantar fasciopathy, patellar tendinopathy, and anterior knee pain. Alterations in the movements at the foot-ankle complex resulting in abnormal


repetitive load can cause injuries at the foot-ankle complex, and more proximally in the kinetic chain.

Motion-control footwear may be effective in reducing (1) the amount of foot pronation during running and (2) running-injury risk among regularly active recreational runners. However, these authors suggest that it is more accurate to investigate the effect of motion-control shoes on the development of injuries specifically related to foot pronation, given that this shoe technology focuses, at least theoretically, on limiting excessive pronation.

The objective of this study was to investigate the effect of motion-control shoes on the development of pronation-related running injuries, which were defined based on existing evidence and/or a theoretically plausible mechanism. The authors hypothesized that motion-control shoes with a medial foot support aimed at reducing excessive pronation would reduce the risk of pronation-related running injuries in recreational runners compared to shoes with no motion-control technology. The secondary aim was to assess whether wearing motion-control shoes influenced the development of other running-related injuries.

The design is a secondary analysis of a randomized controlled trial of the effect of shoes on running injuries.


**METHODS:** Three hundred seventy-two recreational runners were randomized to receive either standard neutral or motion-control shoes



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and were followed up for 6 months regarding running activity and injury. Running injuries that occurred during this period were registered and classified as pronation-related injuries (Achilles tendinopathy, plantar fasciopathy, exercise-related lower-leg pain, and anterior knee pain) or other running-related injuries. With the use of competing risk analysis, the relationship between pronation-related and other running-related injuries and shoe type was evaluated by estimating the cause-specific hazard, controlling for other possible confounders like age, sex, body mass index, previous injury, and sport participation pattern.

**RESULTS:** Twenty-five runners sustained pronation-related running injuries and 68 runners sustained other running-related injuries. Runners wearing the motion-control shoes had a lower risk of pronation-related running injuries compared with runners who wore standard neutral shoes (hazard ratio = 0.41; 95% confidence interval: 0.17, 0.98). There was no effect of shoe type (hazard ratio = 0.68; 95% confidence interval: 0.41, 1.10) on the risk of other running-related injuries.

**CONCLUSION:** Motion-control shoes may reduce the risk of pronation-related running injuries, but did not influence the risk of other running-related injuries.

**IMPLICATIONS:** Clinicians might consider prescribing motion-control shoes for runners who are prone to Achilles tendinopathy, plantar fasciopathy, exercise-related lower-leg pain, and anterior knee pain. 

*Source: Willem's TM, Ley C, Goetghebeur E, Theisen D, Malisoux L. Motion-control shoes reduce the risk of pronation-related pathologies in recreational runners: a secondary analysis of a randomized controlled trial. J Orthop Sports Phys Ther. 2021;51(3):135-143. Used with Permission.*

## Telemedicine for Knee OA Provides Important Patient Benefit

The steadily increasing prevalence and high costs of treating chronic joint pain worldwide poses a challenge for healthcare systems and healthcare payers. New research published in *JAMA Network Open* shows the effectiveness of a digital healthcare treatment with the potential to save insurance companies and their patients the costs and risks of joint surgeries - a finding that is especially promising as more patients turn to telemedicine as a safe treatment option amid the COVID-19 pandemic.

A new randomized controlled trial (RCT) conducted by the University of Nottingham using Joint Academy's (jointacademy.com) clinical evidence-based digital treatment for chronic joint pain is the first to find clinically important improvements of treating knee osteoarthritis (OA) digitally compared to traditional treatment. Patients receiving

*Continued on page 25*

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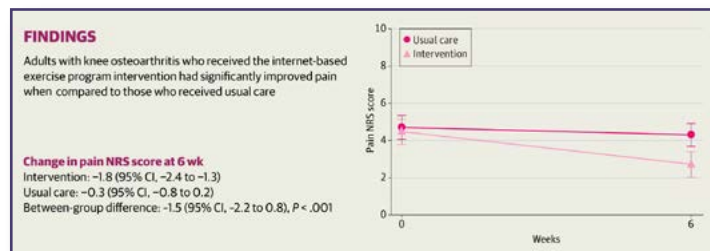
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digital treatment reduced their pain by 41%, while patients receiving traditional care only experienced a 6% decrease.


"We already knew that digital first-line treatment substantially improves symptoms of osteoarthritis at a significantly lower cost than face-to-face care. This study firmly establishes how elective digital treatment actually is in relation to traditional self-management care," said Leif Dahlberg, Chief Medical Officer at Joint Academy and Senior Professor in Orthopedics at Lund University in Sweden.

A total of 105 people, who were 45 years or older with a diagnosis of knee OA, participated in the study and were randomized to 2 groups. One group was treated digitally and the other self-managed their symptoms according to guidelines. Patients in the digital treatment were connected with licensed physical therapists via a smartphone application where they received education and daily exercises. In the other group, patients continued their traditional self-management program and visited their general practitioner when needed.

"The results of the study really show how much can be gained by treating chronic knee pain digitally, and this will help reduce the burden on the healthcare system, especially when we are going through the COVID-19 pandemic where services are already stretched. We hope this study allows health policy-makers to consider the potential in digital alternatives when it comes to treating knee arthritis," said Sameer Akram Gohir, MSc, PhD, physical therapist and researcher at the University of Nottingham, and lead author of the study.

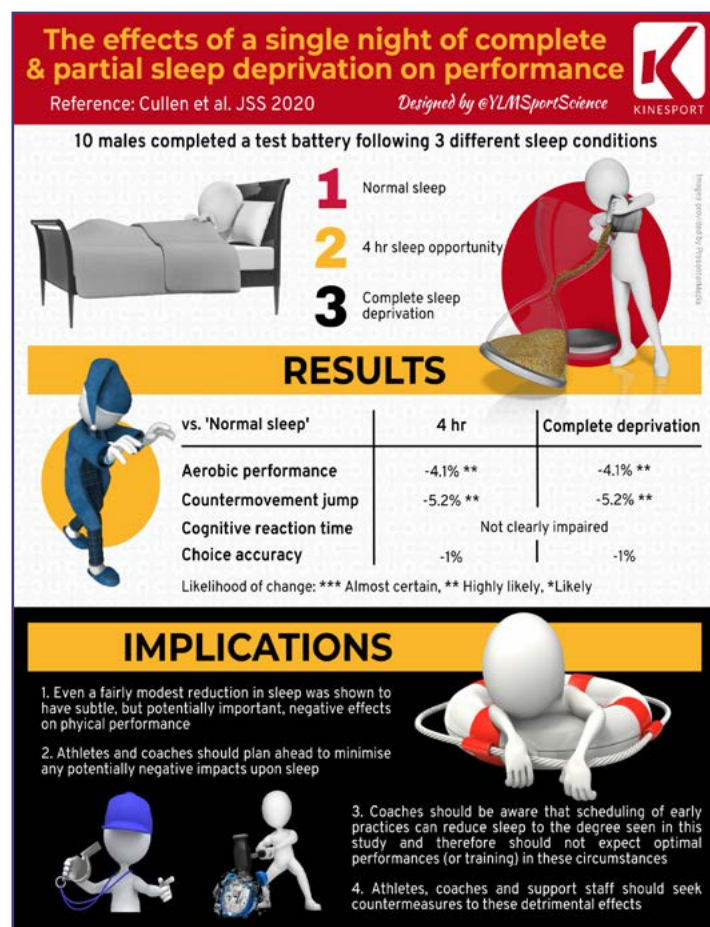
Osteoarthritis is one of the world's fastest growing and most costly chronic diseases. According to the Centers for Disease Control, more than 32 million U.S. adults are affected. It is also among the most expensive conditions to treat when joint replacement surgery is required. For the millions who suffer with the daily pain and stiffness of OA, treatments to slow the progression of the disease are limited. The recommended first-line treatment, consisting of information, exercise and weight control when needed, is underutilized.

"The study shows the positive impact digital treatment has on the OA burden for both patients and healthcare systems. Besides the beneficial outcomes in pain and physical function, the advantages of digital treatment include lower costs as well as making care more easily accessible for those living in rural areas far from the nearest physical therapist," Dahlberg noted.

Joint Academy connects patients with licensed physical therapists through telemedicine. The treatment is now available under certain health plans in the United States and seeking to expand to become available to more providers and patients in 2021. 

**Source:** Gohir SA, Eek F, Kelly A, Abhishek A, Valdes AM. Effectiveness of internet-based exercises aimed at treating knee osteoarthritis: the iBEAT-OA randomized clinical trial. *JAMA Netw Open*. 2021;4(2):e210012. doi:10.1001/jamanetworkopen.2021.0012

## Sleep Deprivation & Performance



**Source:** Cullen T, Thomas G, Wadley AJ, Myers T. The effects of a single night of complete and partial sleep deprivation on physical and cognitive performance: A Bayesian analysis, *J Sports Sci*. 2019;37(23): 2726-2734,

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# GAIT AND BALANCE ACADEMY

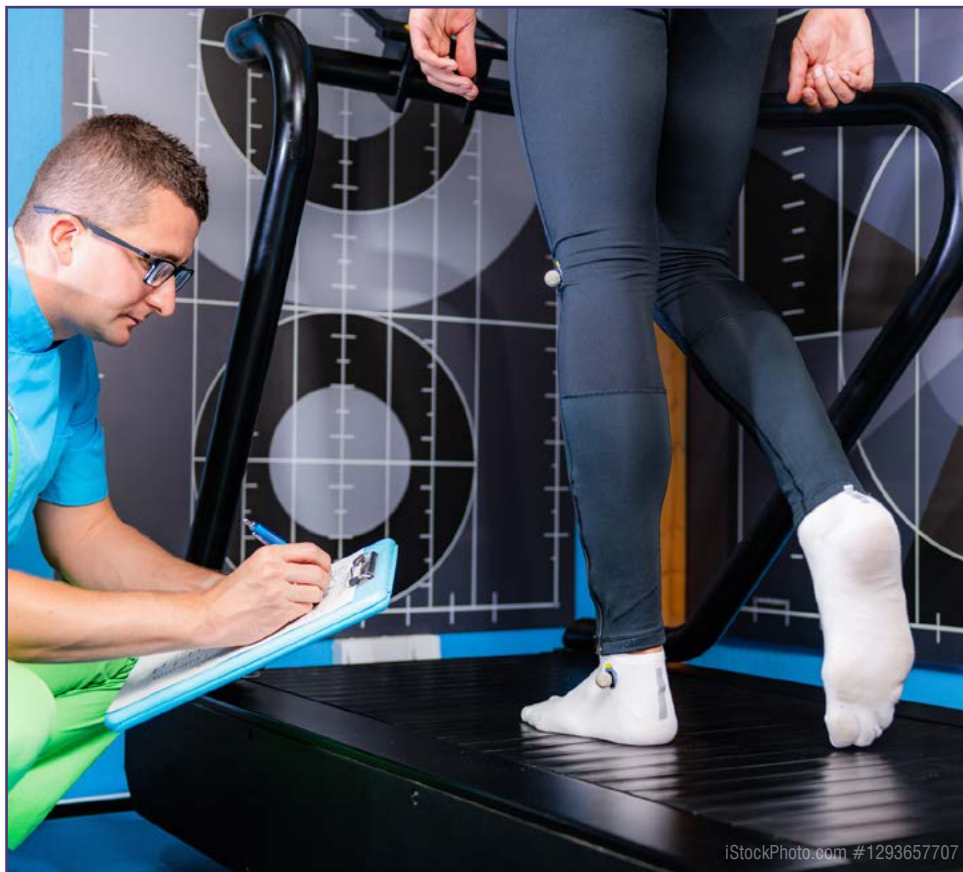
## How Do We Use Gait Analysis to Measure Walking Consistency?

BY ARNAUD GOUELLE, PHD, AND PATRICK ROSCHER, MS

### How do we use gait analysis?

Have you ever asked yourself this simple question: why do we measure and analyze gait? Overall, the answers will revolve around the same ideas: to gauge the functional status of a person; to follow-up the natural history of a disease; to determine immediate or long-term treatment requirement and effects. Now, if the question is what main information are you taking from a gait analysis, answers will surely vary throughout different clinical expertise (see "Of Gait Analyses and Elephants," page 9). An orthopedic surgeon will be interested in deviations in joint kinematics and kinetics; a physiotherapist will look at a more generic level of the motor performance, considering the whole speed or the step length asymmetry; a geriatrician will be interested in quantifying the fall risk or the impact of a cognitive load on the locomotion; a podiatrist will investigate gait at a foot level through the distribution of the weight during the roll-on. Similarly, a person's academic or professional backgrounds guide the perception that a person will have about the use and the interpretation of a clinical gait analysis.

On one hand, this diversity illustrates the recognized value and wealth of gait analysis. While walking seems to be a simple movement, it is in fact a particularly complex function, combining the musculoskeletal and nervous systems with a multifaceted relationship between the automated and voluntary parts of control. From the brain to the effectors, most disturbances in the physical or cognitive status can have an



effect which becomes noticeable in gait features. Even tiny details such as chewing or being in a bad mood change the way you walk, if you know where to look!

On the other hand, these multiple ways to examine gait also highlight a critical fact: whatever the promises, neither a unique system nor a single parameter can address the globality of the gait. With today's technology, there is no way to get a full picture and using any analysis in isolation creates the risk of assessing a patient from a single, incomplete perspective. For example, for individuals diagnosed with

hamstring triceps spasticity and/or bones misalignment, treatments can contribute to changes in the joint motion making it closer to healthy references. However, what is the consequence on the dynamic stability for a person whose locomotion was built on these so-called defects, especially in the first months after surgery? In another example, gait speed is one of the most commonly used parameters and is even suggested as a sixth vital sign of health. However, as the product of step length and cadence, it is possible to produce the same speed by multiple configurations ranging from quick, small steps

This recurring column in LER will seek to present methods, protocols, and outcomes that are appropriate for answering a variety of questions that surround the analysis of gait. LER is proud to partner with the Gait and Balance Academy of ProtoKinetics to provide this technical information. Questions are welcome; please direct them to [gait@lermagazine.com](mailto:gait@lermagazine.com).

*Continued on page 28*

# It must be kept in mind that what a patient does can be related to the disease as well as being the product of coping adaptations, all according to physiological possibilities and limitations.

to slow, long steps. Walking with higher speed than 1 m/s (value often used as a reference) does not mean that the configuration between step length and cadence is optimal. If walking at this pace causes the patient to produce multiple small steps at a fast rate, they could be at higher risk for falls.

The motor control, or how a movement is produced and regulated, is an essential component of gait interpretation; unfortunately, it is often ignored. While it is true that healthy gait is a hallmark, normative references are obviously needed. However, walking with outcomes closer to those seen in control populations does not necessarily imply a better performance. It must be kept in mind that what a patient does can be related to the disease as well as being the product of coping adaptations, all according to physiological possibilities and limitations.

## Who's In Control?

Different Approaches of Motor Control Lead to Different Interpretations of Spatiotemporal Parameters and Variability. In a classical view, the central nervous system (CNS) controls all movements of the body. Coordinated movement patterns, such as walking, require motor planning and constant feedback from the surroundings to regulate the movement by a retroactive control. Consequently, any disorder could affect the production and the regulation of the movement planned by the CNS. Seen under this perspective, increased difference from "normal" walking parameters (for example, a slow walking speed) is seen as a linearly worsening clinical status. Therefore, the invariance of the movement is interpreted as the natural order of the biological system and the variability (for

example, variation in the step-to-step values for step length, stride width or step time) only seen as a reflection of a physiological inability to produce the consistent movement as prescribed by the CNS. Clinically, gait variability is often only interpreted as a "noise" which must be removed, disregarding its potential for regulation.

Another approach considers further the possibility for a self-organization of the movement, to respond to the constraints as much as possible. Outside periods when a direct cognitive intervention is required to take control of the movement (eg, to choose which direction to turn at next street corner), it is postulated that the walking pattern emerges spontaneously from constraints related either to the task (eg, walking under time pressure), the organism (eg, pathological limitations), and/or the environment (eg, walking within a crowd). This implies that the way a person walks and the variability represent much more than the result of physical inabilities. Clinical assessment of gait is standardly administered in straight, unobstructed walking pathway, at self-pace. In this situation, there is no reason to see excessive variability in the gait parameters if there is not an underlying issue. However, if gait variability underlines the existence of an issue, it also demonstrates that the person can regulate the perturbations to walk. Another person walking without variability could be at higher risk for falls than the first patient when faced with a more complex situation, as the low variability could be hiding an inability to adapt.

***Overall, an asymptomatic system must demonstrate control that allows it to be both robust (preserve the homeostasis) and flexible (ability to vary in order to adapt to the constraints).***

## A method to look at organization and variability

In a recent pilot study, Gouelle et al<sup>1</sup> built on these concepts to introduce a scoring methodology based on the walking speed and the relationships between step length and cadence. One method, named the Organization Score, is proposed for looking at the mean gait characteristics and to quantify how much a patient's gait pattern deviates from healthy references. This distance is not seen ultimately as a bad thing, instead it is thought to reflect the biomechanical adaptation and, indirectly, the residual capacity of adaptation which could be mobilizable for the management of internal or external perturbations. Therefore, a second component, the Variability Score, is needed to quantify the level of variability. By applying this method to a cohort of patients with Friedreich ataxia who walked independently, with one cane, or with a rollator, the authors demonstrated that equal levels of organization do not imply a same level of variability and vice-versa. Overall, the Organization Scores demonstrated a longitudinal deterioration in the gait characteristics from independent ambulators to those who ambulated with a rollator. Variability Scores mostly reflected dynamic instability, which became greater as the requirement of an ambulation aid or the switch from a cane to a rollator was imminent. In order to consider both components and the requirement to use an assistive device, the authors finally introduce the Global Ambulation Score (GAS) as a way to summarize the whole performance as a single number. The GAS might be a valuable outcome measure for longitudinal disease progression as it showed

Continued on page 30



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statistical correlation with the clinical status assessed by a standard notation scale for gait ability in Friedreich ataxia.

Gait analysis can be performed using numerous methods that vary depending on purpose for the patient and the background of the clinician or researcher administering the analysis. Due to gait's complexity, it is essential that appropriate analysis tools, protocols, and outcome variables are used, as there is no global test or factor to answer all questions surrounding gait function. The most important process is to define the clinical question that you want to address. Always keep in mind that gait analysis is highly contextual, don't be too quick to extrapolate because the "same" results can have different interpretations in different individuals/under different circumstances. Under standardized conditions in a gait laboratory, the variability mainly reflects disturbances. But, in real-world assessments, with wearable sensors for example, if one is navigating in a crowd, an appropriate ability to regulate gait is necessary for safety. 

Due to gait's complexity,  
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or factor to answer all  
questions surrounding  
gait function.

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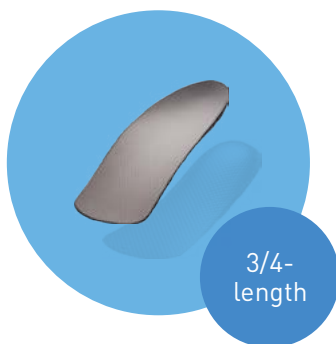
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# COMPARTMENT SYNDROME

## Appreciating Atypical Lower Leg Pain in Athletes

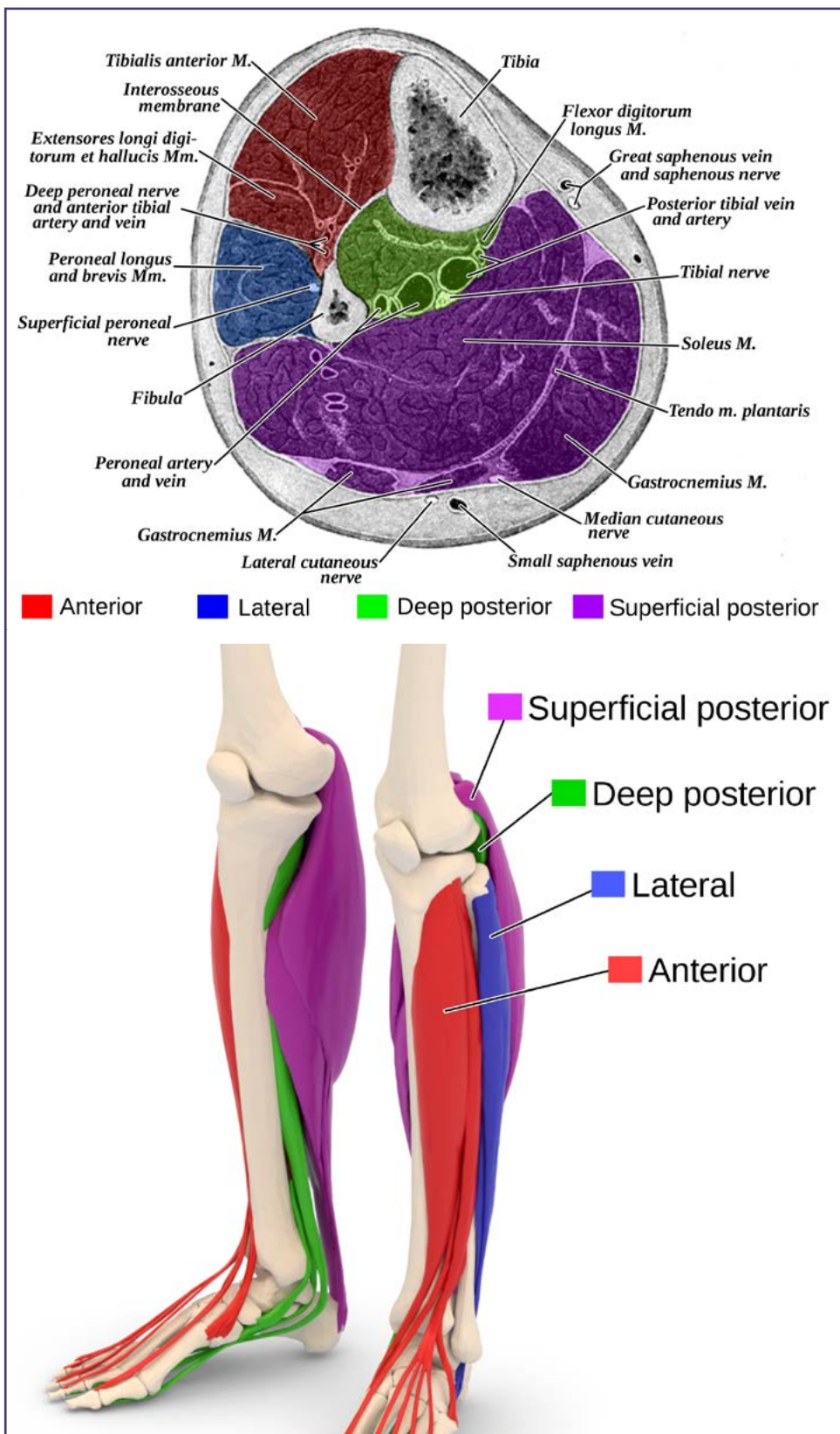
BY HAYLEY IOSUE, DPM, JOSEPH ALBRIGHT, DPM, AND MARK MENDESZON, DPM

Chronic compartment syndrome is an often-overlooked diagnosis in patients who are athletically inclined. With an average 22-month delay in diagnosis, suspicions need to be elevated sooner.

Leg pain in the active and athletic patient population can be difficult to evaluate, diagnose, and treat. A physician must be aware of many causes of lower extremity pain in these patients. Lower leg pain experienced by athletes is typically posterior tibial tendonitis, shin splints, stress fractures, or Achilles tendonitis. Exertional chronic compartment syndrome is not a common diagnosis; however, it is one that is commonly overlooked. There is typically a 22-month delay in the diagnosis and treatment of chronic compartment syndrome and popliteal artery entrapment in patients, and that delay could be detrimental to their athletic career.<sup>1</sup>

Chronic compartment syndrome is caused by increased pressure within the closed fibro-osseous spaces and the anatomic compartments. It is thought to lead to reduced blood flow and tissue perfusion and is associated with repetitive exertion. While it is most commonly seen in the lower leg, it has been described in the shoulder, arms, hands, thighs, and feet. Incidence ranges from 14% to 39% in the general population presenting with leg pain.<sup>2</sup> Typically, this condition is seen in athletics that require running and jumping thus leading to increased intramuscular pressure during training or competition.

Acute compartment syndrome, which is often seen in fractures or crush injuries to the extremities, represent emergencies and are outside the scope of this article.



Continued on page 34



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## Anatomy Is Key

It is imperative to understand the anatomy in the evaluation, diagnosis, and treatment of chronic compartment syndrome. Historically, the lower leg has been described as four compartments. Each compartment contains individual muscles, nerves, arteries, and veins, encased in its own fascial membrane.

- The anterior compartment contains the anterior tibial artery, deep peroneal nerve, extensor digitorum longus, anterior tibialis, and extensor hallucis longus.
- The lateral compartment encloses the superficial peroneal nerve and the peroneus longus and brevis muscles.
- The superficial posterior compartment contains the sural nerve, the medial and lateral heads of the gastrocnemius muscles, and the soleus muscle.
- The deep posterior compartment contains the tibial nerve, posterior tibial artery, peroneal artery, the flexor digitorum brevis, and the flexor hallucis brevis.
- A more recent theory is that there is a fifth compartment which is made up only of the posterior tibialis muscle with its own fascial covering.<sup>3</sup>

Chronic compartment syndrome most commonly involves the anterior and lateral compartments.<sup>4</sup>

During repetitive and strenuous exercise, muscle fibers can swell up to 20 times their resting size. This is due to increased blood flow and edema, which can cause a 20% increase in muscle volume and weight.<sup>5</sup> A normal compartment is able to accommodate such physiological changes during exercise; however, a non-compliant compartment will lead to increased intra-compartmental pressures. In a non-compliant compartment, the increased perfusing blood volume, muscle hypertrophy, and increased interstitial fluid volume will allow increased pressure in accordance with Laplace's law. This law explains that a capillary membrane subjected to internal and external pressures reaches an equilibrium based on those forces. This equilibrium will cause a decrease in both arteriolar flow and venous return. In non-compliant compartments, it is thought that blood flow becomes insufficient to meet the requirements of the muscle, thus creating pain with activity.<sup>6</sup>

The pain was originally thought to be an ischemic pain related to the decreased oxygenation of the tissues, insufficient muscle perfusion, and decreased return. However, some studies have found that this may not be the case. Amendola et al<sup>7</sup> used nuclear medicine blood flow studies to evaluate alterations in the muscles during chronic compartment syndrome, and saw no ischemic changes in the muscles. Balduini et al<sup>8</sup> used P-NMR spectroscopy to evaluate for ischemic changes in the muscle. They found that ischemic changes only occurred at very high pressures (>160mmHg) which are typically not seen in exertional compartment syndrome. Another theory is the pain is related to the stimulation of the fascia or the periosteal sensory nerves related to the increased

pressure within the compartment. The local release of kinins along with reduced blood flow could also be another source of the pain.<sup>9</sup>

## The Physical Exam

A thorough history and physical exam is crucial to the diagnosis of compartment syndrome. The trick is to watch these patients exercise first and examine them immediately afterward.

The patient will describe a history of pain with chronic exertion. Athletes typically performing a repetitive exercise describe a dull ache that begins around the same time or distance during their exercise; the pain worsens to the point that they must stop. This pain will be relieved by rest. The patient also may describe a tightness or stiffness in their legs. In more advanced cases, patients can also experience transient numbness, tingling or drop foot. At rest, a patient's physical exam is normal: the patient will have no signs or symptoms at rest. In about 40% to 60% of patients, fascial herniation is present during an at-rest exam.<sup>10</sup> However, after these patients exercise, the exam has more significant findings: The compartments will appear tense, firm, and occasionally, the skin will appear shiny. The patient may have weakness or decreased sensation in the foot.

The differential diagnosis for leg pain includes, but is not limited to, stress fractures, stress reactions, bone tumors, complex regional pain syndrome, radiculopathy, and popliteal artery entrapment syndrome.

Imaging may be useful in the diagnosis of chronic compartment syndrome but it is not the mainstay of diagnosis. Plain radiographs can be useful to help rule out stress fractures, reactions, or other bony abnormalities. An MRI can be utilized to see if there is any structural or soft tissue anomaly that may compress the popliteal artery. Bone scans have been utilized to show an ischemic compartment if needed. The gold standard test for diagnosing compartment syndrome is compartment pressure testing at rest and with exercise.

Compartment pressure measurements can be done with a wick catheter, slit catheter, microtip, microcapillary infusion, or a needle manometer. Measurements should be taken at rest, and then within 1 minute of exercise and then at 5 minutes post-exercise. The patient should be lying in a comfortable position with the foot plantarflexed at 20 degrees and the knee in 10 to 30 degrees of flexion. Measuring the compartment pressures can be difficult so it is important to be familiar with the anatomy and equipment being used for measurements. Pedowitz et al<sup>11</sup> defined a set of criteria to diagnose chronic compartment syndrome. At least 1 of the following 3 criterion has to be present: a resting pressure greater than or equal to 115mmHg, a measurement taken 1 minute post-exercise greater than 30mmHg, or a measurement taken 5 minutes post-exercise greater than 20mmHg.

## Treatment Options

After a diagnosis of chronic exertional compartment syndrome is made, treatment options will need to be discussed with the patient. Few conser-

*Continued on page 36*

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# Peripheral Artery Disease

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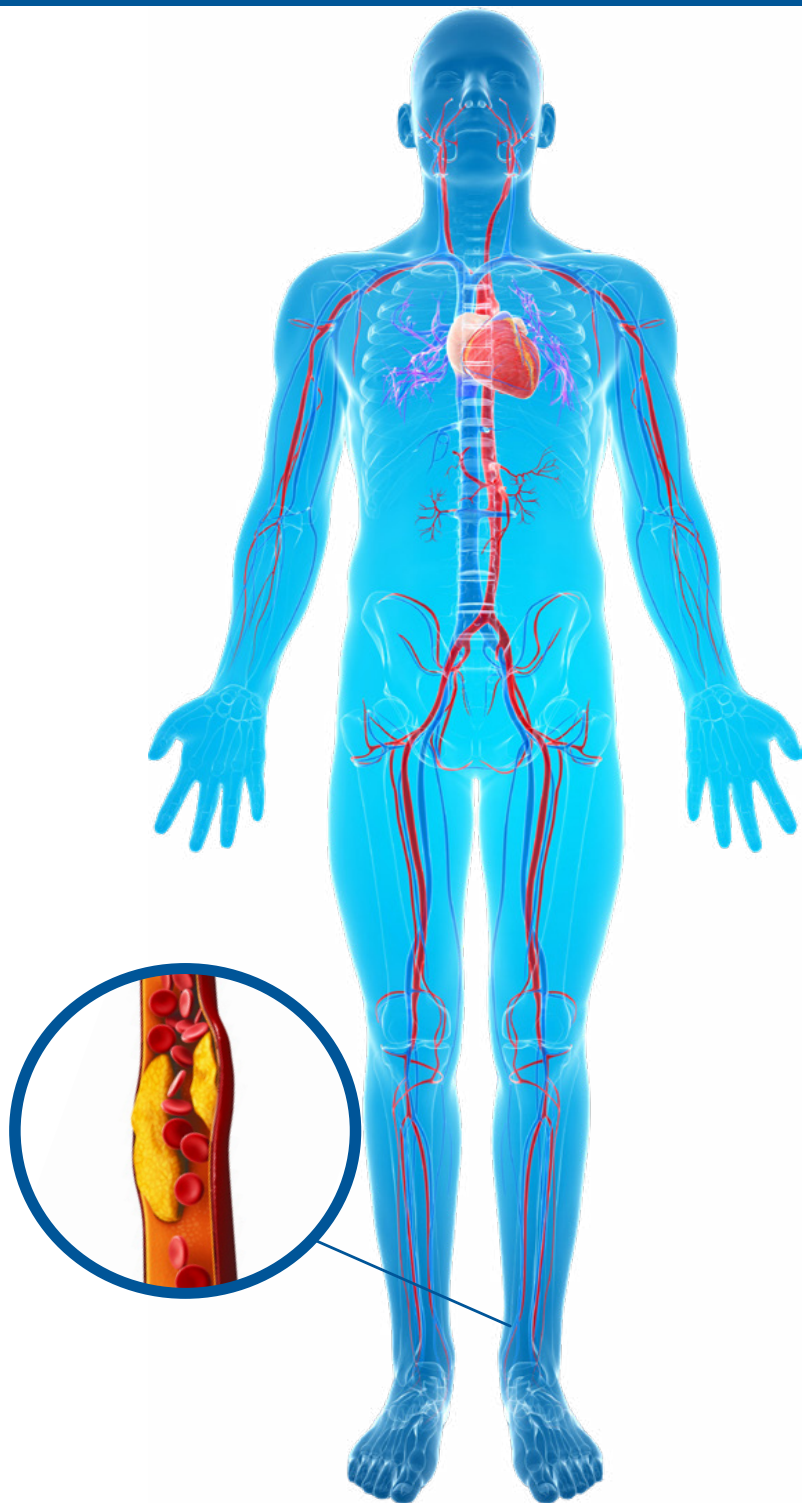
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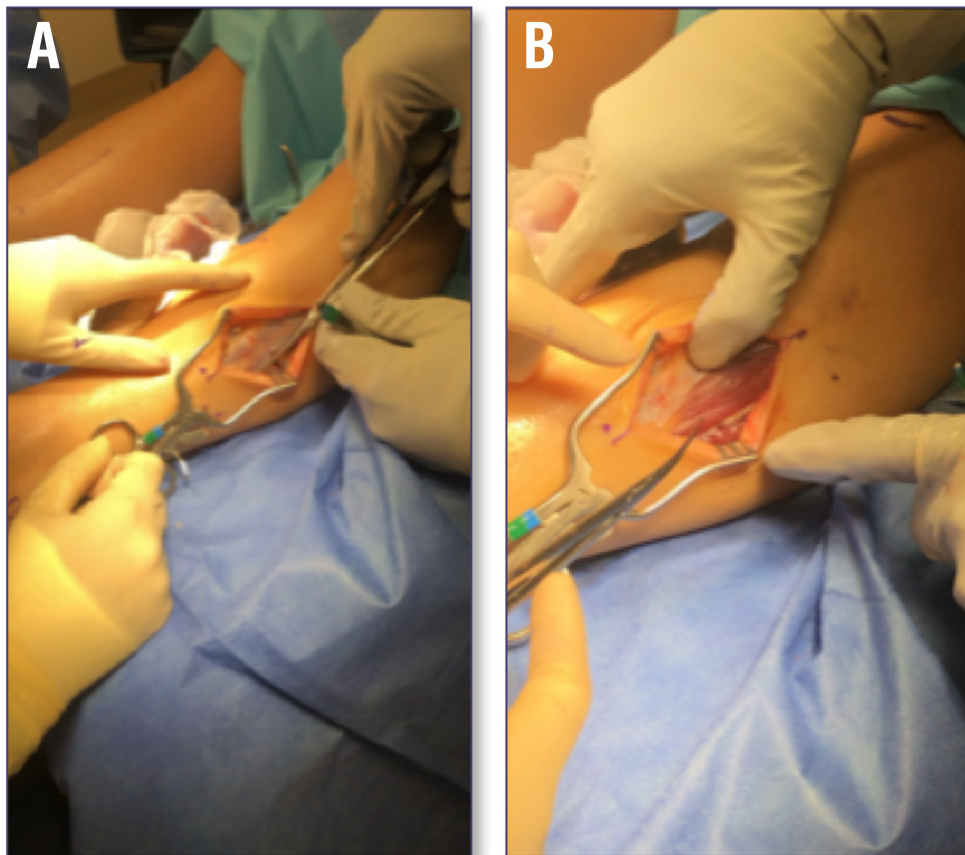
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vative treatment options are typically amenable to these patients. The patient can stop the activity which aggravates the symptoms; however, many patients are not agreeable with this option. The patient can try rest, NSAIDs, and/or ice to help alleviate the symptoms. Blackman et al<sup>12</sup> found that massage therapy was helpful in 7 patients in a retrospective cohort study. After a 5-week massage and stretching program, the patients were able to increase the amount of work performed during exercise before the symptoms developed.

Many of these patients will elect to undergo surgical intervention with fasciotomies of the affected compartments. The fasciotomies can be done endoscopically or open. The procedure aims to release the affected compartment. To release the anterior and lateral leg compartments, an approximately 10cm longitudinal incision is made over the anterior lateral aspect of the leg between the tibial crest and the fibula. The anterior intermuscular septum between the compartments must be identified and the compartmental fascia can be released. A similar 10cm-incision on the medial aspect of the leg is utilized to access the superficial and deep posterior compartments. The superficial posterior compartment is easily identified and can be released directly but with cautious awareness of the neurovascular structures. To reach the deep compartment, undermine anteriorly and reach the posterior margin of the tibia, then detach the proximal soleus to visualize the deep posterior compartment and release it. In most instances, after adequate compartment release, skin closure is all that is needed as the surgeon does not want to compress the compartments again. The lower extremity can be placed in a soft dressing.

Post-operatively the patient can begin ice and elevation immediately. Active range of motion of the lower extremity can begin as tolerated. Weight bearing is allowed as tolerated. Typically, in 3-4 weeks post compartment release, the patient can begin to return to normal activity gradually.

The literature reports about a 4.5% to 11% complication rate associated with compartment release in the lower extremity. Most common



**Figure 2.** Surgical approach to anterior lateral compartment release: A) before fascial release; B) post-surgical release. Photos provided by the authors.

complications noted are hemorrhage, infection, nerve entrapment, swelling, artery injury, hematoma, seroma, and deep vein thrombosis. Risk of recurrence of the exertional compartment syndrome is also possible, with a reported repeat rate of 3% to 12%.<sup>10</sup>

Campano et al<sup>2</sup> completed a systemic review of the literature and found that 81% to 100% of the patients with chronic exertional compartment syndrome have pain relief after fasciotomies. The deep posterior compartment releases are less successful with a rate of 50% to 60%. Additionally, primary operative management of chronic exertional compartment syndrome was found to be successful in treating two-thirds of young athletic patients and 84% of patients were satisfied with their surgical outcomes at short- to mid-term follow up.

## Popliteal Artery Entrapment

Popliteal artery entrapment syndrome has the most similar presentation to exertional compartment syndrome. In patients where

chronic compartment syndrome is suspected, one must also examine and test for popliteal artery entrapment. Popliteal artery entrapment syndrome occurs when the popliteal artery becomes compressed by one of the calf muscles, typically the medial head of the gastrocnemius during exertion. This reduces blood flow to the leg and decreases oxygen perfusion to the muscles of the lower extremity. This leads to calf pain, cramping, and discomfort during exercise. The patient can also experience paresthesia and numbness. The symptoms are relieved by rest. The symptoms present remarkably similar to exertional chronic compartment syndrome. Testing for popliteal artery entrapment includes noninvasive vascular studies with exercise to evaluate the perfusion during exercise and with different leg positions. These patients are also typically evaluated by a vascular surgeon. An MRA (magnetic resonance angiogram) or CTA (computed tomography angiography) of the knee and tibia-fibula is typically ordered to evaluate the position of the popliteal artery

Continued on page 39



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# Risk of recurrence of the exertional compartment syndrome is also possible, with a reported repeat rate of 3% to 12%.

relative to the other structures in the popliteal fossa. If these studies are inconclusive, a diagnostic angiogram can be obtained. If the patient is diagnosed with popliteal artery entrapment syndrome, treatment options include ceasing the activity which aggravates the symptoms or pursuing surgical intervention. Referral to vascular surgery or plastic surgery would be necessary at this step if surgical intervention for popliteal artery entrapment is needed. The goal of surgical intervention is to restore the abnormal relationship of the popliteal artery and the medial head of the gastrocnemius muscle and to decompress the four compartments of the leg. After surgery, vascular claudication is resolved rapidly, and the patient is typically able to return to activity. Post-operative MRA is typically performed around 4 months post-operatively to confirm adequate circulation.<sup>13,14</sup>

## Conclusion

In conclusion, chronic exertional compartment syndrome and popliteal artery entrapment conditions are atypical causes of lower extremity pain in athletic patients. Both conditions should be ruled out in the work up of chronic lower extremity pain. After proper diagnosis and medical work up, most patients typically respond favorably with surgical intervention and aggressive post-operative physical therapy and rehabilitation. 

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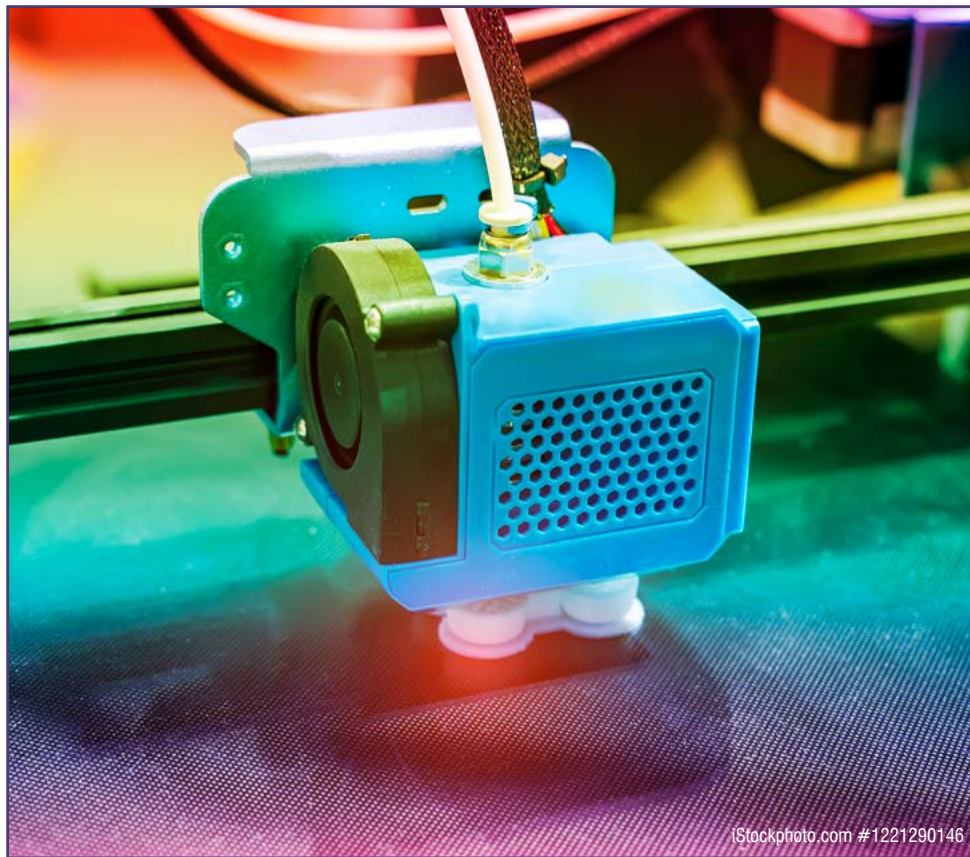
# How I Learned to Love Digital O&P

BY TERRELL S. TATE, BOCPCO

In 2012, I entered the digital world of orthotics and prosthetics (O&P), but did not fully understand the potential. The practice was a traditional brick and mortar O&P company with a satellite location. The business was built around spinal orthotics, but prosthetics was the target for future growth as the demand for spine bracing continued to decline. As a co-owner, we talked about changing to outsource fabrication as a means to contain costs. But the idea of outsourcing fabrication was very difficult to consider since the practice was built around in-house fabrication for 95% of all orthotics and prosthetics. After making the decision to close in-house fabrication, we shifted our workflows away from traditional hand-casting with plaster model rectification and began to scan all impressions for lower extremity orthotics and digitally scan all amputees.

We utilized one person to scan all of the impressions for LE orthotics and then he and I shared the digital modeling responsibilities. However, as the only prosthetist, the design work for prosthetics was all my responsibility. This was my tutorial: trial and error. Since we outsourced all fabrication, I had to evaluate the fitting problems and decide if they were design flaws or technical fabrication flaws. Early on, the errors were mostly design and my responsibility. However, I was able to learn and understand how the scan and design combine to create a finished product that was more accurate and precise than what I could achieve using traditional methods.

After gaining an understanding of better shape-capture technique, and then some basic rule sets for model design, there was only one aspect of fabrication that was inconsistent. The alignment of the adapter was at times perfect and other times off by a small amount. And though this small amount could be corrected with an alignment adapter, I understood the



potential for achieving a socket that would be perfect. At that time, the outsource partner was carving the model and then manually placing the adapter. I wanted to eliminate the technical possibility for human error.

3D printing was able to finally provide the last element of control that I desired. Admittedly, I am very picky about alignment. Especially on a patient that is atypical and I have already been through the learning curve to understand the alignment. My thought was this: if I can see the perfect alignment in the design software, then I should be able to have a perfectly fitting finished product.

When I am able to place the adapter in position during the model design phase, I have found that I have little to no adjustments to make during dynamic alignment. The power of this aspect of 3D-printed test sockets is, to

my mind, what will truly save time and money in clinical practice. While some consider the fabrication process simplicity of 3D-printed test sockets, reduced manual labor, and reduced material cost to be the key to time and money, I believe that a test socket which is perfect in shape, soft tissue tension value, and alignment to offer the greatest value. Clinician time is a premium, and the value of maximizing this time offers the greatest potential for effecting business in total.

For those clinicians and business owners who have also realized this potential, many question the reliability of 3D-printed sockets. This is a legitimate concern. I have experienced separation between the inner and outer walls, failure of the z axis, and improper wall thickness. Some of this was due to the nature of FDM (formed deposition modeling) as a

*Continued on page 42*

3D-print method. Other was due to my shell creation. I currently use Ossur Design Studio (Ossur Americas, Orange County, CA) for model design. I have found great success in shape design. However, in my experience, the shell creation tool has a limitation in that it does not always generate a structurally sound design.

Fabrication partners, such as Extremit-i3D LLC (Johns Island, SC), have tested their designs for the structural integrity needed to safely ambulate on a test socket. Barry Hand, mechanical engineer and founder of Extremit-i3D, presented a research study at the American Academy of Orthotists and Prosthetists annual meeting titled, Strength Testing of Definitive 3D-printed Transtibial Prosthetic Sockets (now in print at J Prosthet Orthot. 2020;32(4):295-300). Interestingly, they learned that there is little to no evidence for strength-testing prosthetic sockets fabricated using conventional methods. The international ISO standards for structural integrity were used in the non-patient

My thought was this:  
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alignment in the design  
software, then I should  
be able to have a  
perfectly fitting finished  
product

research to test the structural integrity of their design. The design was tested using ISO10328 cyclic testing and did not fail testing to 3 million cycles. The significance is that in a digitally printed socket, the validation of strength is possible because the design is reproducible and exactly the same, just under different specifications. Could more research like this be utilized to test the failure rate of socket designs in the

future? Of course, and this would also lead to a new set of standards for socket manufacturing.

Current technology in 3D printing offers many new business solutions and design/manufacturing possibilities. PVA Med (Cohoes, NY) has a pre-integrated, standards-based solution for scanning, model design, and check socket fabrication. They utilize preconfigured profiles that simplify slicing (the parameters are understood by the printer for building the check socket layer by layer) to create the check socket design which can be sent directly to the PVA printer with the click of a button. The PVA Med approach is focused on simplification, repeatability, and ease of use. Most clinicians can adapt to the digital design world as we understand the positive plaster model and can transport that knowledge to the computer screen. However, the software expertise needed to design the actual socket in CAD is not a common part of our knowledge set. Although this is not native to prosthetists, several

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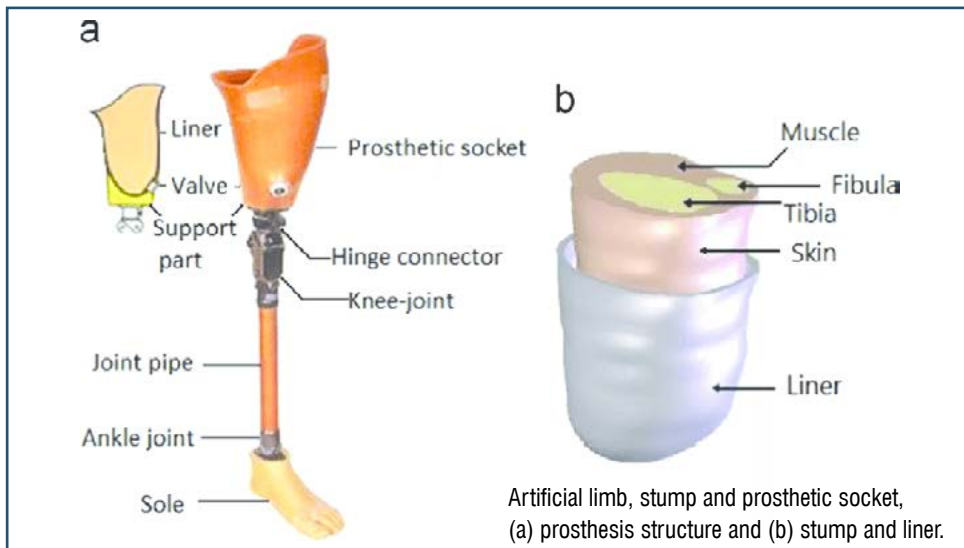
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clinicians have dived deeply into digital socket manufacturing.

Brent Wright, CPO, formed Additive America (Kinston, NC). At Additive America, they are printing parts with the HP Multi Jet Fusion (Palo Alto, CA) and using Geomagic Freeform (3D Systems, Rock Hill, SC) as the software for socket design. Brent wants to help bridge the gap and serve as a resource to others who want to have 3D printed test and definitive sockets. Additive America offers socket design and definitive socket fabrication for all clinicians and Brent is very open to sharing how he uses these digital tools. The technology for multi jet fusion offers a much stronger link in the z axis which has a general strength advantage over FDM methods thus producing a reproducible product with low failure rate.

The 3D printing technology is growing quickly and through discourse, research, and collaboration we will all be able to offer socket designs that are not possible with conventional



Artificial limb, stump and prosthetic socket, (a) prosthesis structure and (b) stump and liner.

methods. The next generation digital prosthetist will be able to scan, design, and fabricate with greater precision and ultimately lead to better patient compliance and outcomes. 

*Terrell S. Tate, BOCP, CO, is founder and chief executive officer of MPower Health in Memphis,*

*TN. Terry has been a prosthetist for more than 15 years and an orthotist for more than 25. He'll be using this space on a regular basis to discuss all things technology related to the lower extremity. Reach him on LinkedIn for more about digital O&P technology.*

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# FALLS IN PEOPLE WITH MULTIPLE SCLEROSIS, PART II: Risk Identification, Intervention, and Future Directions

BY SUSAN COOTE, PhD; LAURA COMBER, PhD; GILLIAN QUINN, PhD; CARME SANTOYO-MEDINA, MSc; ALON KALRON, PhD, PT; HILARY GUNN, PhD

Falls are highly prevalent in people with multiple sclerosis (MS) and result in a range of negative consequences, such as injury, activity curtailment, reduced quality of life, and increased need for care and time off work. This narrative review aims to summarize key literature and to discuss future work needed in the area of fall prevention for people with MS. The incidence of falls in people with MS is estimated to be more than 50%, similar to that in adults older than 80 years. The consequences of falls are considerable because rate of injury is high, and fear of falling and low self-efficacy are significant problems that lead to activity curtailment. A wide range of physiological, personal, and environmental factors have been highlighted as potential risk factors and predictors of falls. Falls are individual and multifactorial, and, hence, approaches to interventions will likely need to adopt a multifactorial approach. However, the literature to date has largely focused on exercise-based interventions, with newer, more comprehensive interventions that use both education and exercise showing promising results. Several gaps in knowledge of falls in MS remain, in particular the lack of standardized definitions and outcome measures, to enable data pooling and comparison. Moving forward, the involvement of people with MS in the design and evaluation of programs is essential, as are approaches



to intervention development that consider implementation from the outset. *Int J MS Care*. 2020;22:247-255.

The incidence of falls in people with multiple sclerosis (MS) is high, and the consequences of falls are far-reaching for both the person and the health care system. This important topic has received increasing attention as researchers and health care professionals aim to identify the risk factors, context, and consequences and to use these data to develop theory-based interventions. This narrative review and position paper is written by members of the Special Interest Group on Mobility of Rehabilitation in Multiple Sclerosis

(RIMS, the European network for best practice and research in MS) and aims to summarize the key literature in the area and to identify gaps in knowledge, challenges, and ways forward. Part I covered the Incidence of Falls, Consequences of Falls, Factors Associated with and Predictive of Falls, and Conclusion and Way Forward.

## Treatment

Given the complexity in causes and risk factors of falls in MS, a multifactorial approach seems to be the most appropriate strategy; however, much research to date considers exercise only. Two systematic reviews of interventions to

**Editor's Note:** Part I of this series appeared in our March 2021 issue, page 37. Part II picks up with Treatment, Gaps in Knowledge, and Challenges. This 2-part series appears with permission from the Consortium of Multiple Sclerosis Centers; references have been deleted for brevity, but can be found with the original article at the URL below. The original article, "Falls in People with Multiple Sclerosis: Risk Identification, Intervention, and Future Directions," by the same authors, appeared in the *International Journal of MS Care*. 2020;22:247-255, available at <https://meridian.allenpress.com/ijmsc/article/22/6/247/443994/Falls-in-People-with-Multiple-SclerosisRisk>.

Continued on page 46

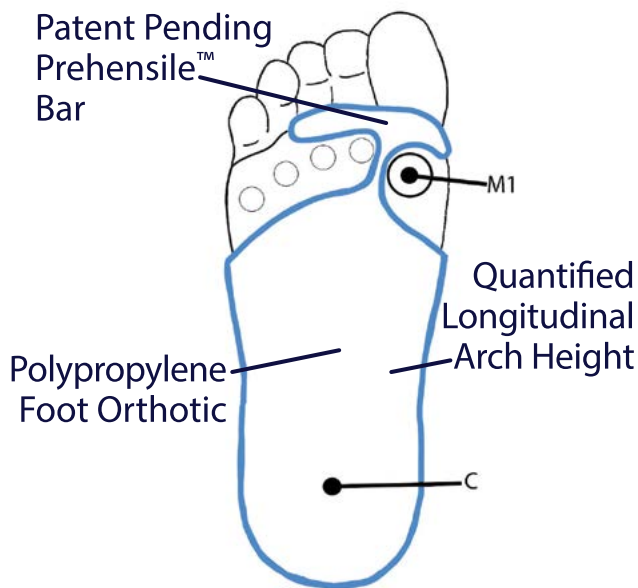
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reduce falls exist. Sosnoff and Sung identified ten studies, four of which were randomized controlled trials (RCTs) with a total of 524 participants. The increased focus on this topic resulted in 13 RCTs being included in a recently published Cochrane review. In contrast, a systematic review of exercise interventions for fall prevention in older adults included 108 RCTs with 23,407 participants living in the community in 25 countries. Most MS studies with exercise interventions included conventional balance, sensory-specific, and game-based exercises. Most trials demonstrated a reduction in actual falls and/or fall risk, most often with a concurrent improvement in balance and/or mobility. Despite these encouraging findings, firm conclusions could not be drawn due to the heterogeneity in study designs, small sample sizes, lack of assessor blinding, and limited use of prospective fall monitoring. The review authors highlight the need for additional knowledge regarding risk factors for falls in people with MS and suggest implementation of targeted multifactorial interventions examining both physiological and behavioral risk, as advocated by the International MS Falls Prevention Research Network (IMSFPN).

A related review concerning interventions to improve balance in people with MS found that specificity is important (ie, balance and functional exercises had the largest effect on balance) and that dose of intervention is related to outcome. Sherrington et al suggest that more than 50 hours of intervention is required to improve balance, yet, to our knowledge, no study in the MS field has examined an intervention program at this dose. The literature about older adults consistently finds that exercise interventions, although effective, are more impactful as part of multiple-component or multifactorial interventions.

Unfortunately, the strong evidence for multifactorial and multiple-component interventions in older fallers are sparsely replicated in MS. To date, only four multifactorial interventions have been published in MS. Hugos et al performed a retrospective evaluation of an existing exercise and education program for fall prevention in people with MS using the Free from Falls program for older adults with adaptations made for MS-specific symptoms such as fatigue. However, the retrospective nature of the study and the lack of a control group necessitates caution when interpreting these findings, which were a reduction in fall rates and improved balance performance and confidence. Sosnoff et al evaluated a multifactorial approach based on the Safe at Home BAASE program. Their pilot RCT of 34 participants compared four groups: waitlist control, home exercise alone, education targeting behavioral risk, and a combination of home exercise and education. The authors found a reduction in risk of falls for the groups engaged in an exercise component, although with mixed findings for the combined exercise and education arms. Limitations included underpowered sample size and lack of prospective fall monitoring before the intervention. Thus, further research examining multicomponent fall prevention interventions for people with MS is needed.

Interventions addressing personal and environmental factors associated with falls are lacking. For example, fear of falling and fall risk are not

## Exercise interventions, although effective, are more impactful as part of multiple-component or multifactorial interventions

only associated with falls but are independent fall risk factors, yet to date have had limited attention in interventions. The strong evidence from the older adult literature and our increasing understanding of the role of psychological and environmental aspects of falls in MS suggests that future interventions should address both aspects and be tailored to the individual risk factors and physiological/psychological profile. Therefore, we encourage future trials to investigate the efficacy of adding supportive features (eg, grab bars or handrails) in locations such as stairs and bathrooms in homes of people with MS. In addition, future research should examine the impact of fall prevention programs that include education around the use and training of walking aids or increasing awareness of the outdoor environment and situations that might lead to falls. Other environmental harm-minimization elements, such as fall monitoring devices or pressure sensors, also have not been addressed to date. Another element is that of harm minimization through fracture prevention via routine preventive bone density assessment and intervention to improve bone loss if it presents.

Recent studies have investigated the views and opinions of persons with MS in relation to what they would consider the optimal fall prevention program, highlighting their preference for practical, personalized interventions with peer interaction and ongoing support (either in groups or by other media). Balance/strength exercises and fall prevention/management techniques, as well as services regarding mobility aids and home modification from trained professionals (eg, occupational therapists and physiotherapists), might be included. Something remarkable is that people with MS recognize that personal factors, such as the competence of knowing and accepting their capacity to engage in activities, are crucial in preventing falls.

### Gaps in Knowledge

To increase our understanding of falls in people with MS and, hence, their treatment, there are several gaps in knowledge that require attention. Balance impairment is associated with and predictive of falls, but our understanding of what particular postural control deficits are associated with falls is limited. Determining what postural control deficit or what element of balance (eg, proprioceptive deficits, reduced strength, cognitive motor interference, or reaction time) is most associated with falls will allow more targeted and tailored approaches and could potentially increase the efficacy of exercise interventions.

*Continued on page 48*

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# Determining what postural control deficit or what element of balance is most associated with falls will allow more targeted and tailored approaches

In addition, our understanding of the protective versus predictive nature of these deficits and their contribution to falls is limited. For example, if an individual walks at a slower gait speed with a wider base of support, this may be a compensatory mechanism to increase stability. Therefore, attempts to normalize this pattern of gait, such as increasing speed, may be inherently disadvantageous to reducing fall risk. Similarly, if imbalance occurs due to fast walking speed, a reduction in gait speed may be seen as a positive outcome of intervention. Longitudinal observational studies of clinical measures and posturography should be implemented, with fall incidence assessed prospectively before and after assessment. Such investigations may enable more targeted rehabilitation strategies for fall prevention in people with MS.

An associated issue is the choice of balance measures used to establish fall risk. For example, people with MS fall while standing, turning, and walking, yet many balance measures capture balance with feet in a static position. Posturography seems promising as a fall risk tool, but the static foot plate does not mirror the dynamic activities where falls occur, and access to this in many clinics is limited, with some systems requiring technical expertise. The use of sensor-based measures of balance during gait may be an option worth pursuing because it would allow the collection of ecologically valid postural control data, potentially in remote settings.

When conducting studies to evaluate multiple component risk prediction tools, the model first needs to be developed, and it subsequently needs to be validated; none of the existing MS fall risk prediction tools have been validated to date. The model development study often tends to overestimate predictive ability of a model, either due to overfitting if the sample size is small

or if there are too few outcome events relative to the number of predictor variables. External validation applies the model and assesses its predictive performance for a new sample who were not involved in the model development study. Model impact studies are recommended after external validation to assess the effect on the change in behavior of clinicians, on cost-effectiveness, and on health outcomes. In addition to including analysis of the traditional predictive values (eg, sensitivity, specificity, area under the curve), impact studies must also consider safety and efficiency.

Arguably fall prevention interventions for people with MS are in their infancy, although the start is promising. One concern is the mismatch between the range of physiological and psychological risk factors and the predominance to date of exercise-only interventions; however, more recent interventions are acknowledging this and evaluate multiple-component and multifactorial interventions. Intervention development is complex, and for this multifactorial, variable, and individualized problem, the challenges will be many. Frameworks such as the Medical Research Council (MRC) development of complex interventions may assist with this challenging process. An additional consideration as this field progresses is the need to articulate the theory behind the interventions, an aspect of intervention development for which the rehabilitation field has previously been criticized. It is essential that transparent dissemination of the development processes behind complex interventions occurs and that theoretical underpinnings and mechanisms of intended action are clearly articulated so that the intervention is developed in line with best practice.

It is likely that a range of interventions considering either group or individual treatment, using face-to-face or remote methods and

in-hospital, outpatient, and community settings, and with a range of international health care and social contexts will be needed; one size certainly will not fit all for the issue of falls in MS.

## Challenges

One key challenge in pooling and comparing data is the lack of standardization of fall definitions, faller classifications, and fall outcomes to date. The use of frameworks such as Core Outcome Measures in Effectiveness Trials (COMET) to develop and apply core outcome sets for MS fall interventions is recommended to overcome the current issue of multiple definitions, classifications, and outcomes. Most concerning is the limited input to date from people with MS in deciding study outcomes, which requires attention in future work.

The issue of “dose” of intervention required to improve postural control is a challenge, and a fine balance between the optimal dose/duration and the practicalities involved in engaging with and delivering such a program needs to be considered. Evidence from a range of groups highlights sustained engagement as a major challenge to fall prevention interventions and suggests that programs need to be easy to access, perform, and embed into a person’s daily life for initial improvements to be sustained. There are also significant resource implications in the provision of such interventions that may challenge existing models of health care. Supplementing face-to-face delivery with the provision of Web-based resources or telephone or e-mail contact to support engagement seems promising, as do programs that embed a supported self-management approach.

Perhaps the greatest challenge in reducing fall risk and, hence, falls is variability. Presentations and symptoms of MS (and thus fall risk



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factors) vary significantly between people and over time, which necessitates flexible intervention programs that can be individually targeted and that support people to be able to self-assess their changing symptoms and adjust their programs effectively on an ongoing basis. Additional variability in personal, environmental, and social factors means that programs need to be adaptable and responsive to needs and circumstances. Such programs require input from highly trained clinicians who are supported to use a wide range of skills and present feasibility and sustainability issues for many models of health care delivery. For researchers, this degree of variability is also a significant challenge, particularly in achieving a high degree of flexibility in program provision while maintaining the degree of standardization and intervention fidelity necessary to ensure methodological rigor in clinical trials. Collaboration, nationally and internationally, will be vital for recruiting sufficient numbers of people to undertake the large-scale studies that are essential to develop a robust evidence base, although the variety of health care settings internationally adds another challenge.

The introduction of wearable electronic technology, worn on the body or embedded into mobile and portable solutions (smartphones, watches, etc.), creates a new challenge for those investigating falls in people with MS. Although the potential of these devices to identify risk factors for falls is clear, their benefits are still to be verified. Importantly, these devices enable the research field to detect movement behavior of people with MS outside the laboratory and/

## Supplementing face-to-face delivery with the provision of Web-based resources or telephone or e-mail contact to support engagement seems promising

or clinical facilities. This opportunity might uncover new “real-life” risk factors that were not previously considered.


## Conclusion and Way Forward

It is probable that we cannot prevent all falls; however, our aim should be to prevent as many falls as possible. Falls that require medical attention are particularly burdensome for both the person and the health care system and might be prioritized; however, even minor falls may have a profound effect on well-being and on activity participation and, therefore, warrant intervention to prevent them.

Falls are common and have a wide range of negative effects. Research to date suggests that there are a variety of physiological, personal, and environmental factors that contribute to falls for people with MS; a better understanding of these factors will lead to improved risk prediction tools and interventions for this cohort. Interventions to date have largely comprised exercise-only interventions; these show promise and suggest that challenging, functional balance programs

targeting individual risk factors, which are structured to support people to engage at a high intensity over a long duration, are most likely to be effective. However, large-scale effectiveness trials are urgently required to determine the key components that should form the basis of MS fall exercise interventions, regardless of delivery method or health care setting.

Given the range of issues contributing to falls in MS, future interventions should consider other aspects of fall risk, particularly the psychological and MS-specific risk factors. This also necessitates a recognition that not all risk factors will be modifiable and that people will often choose to accept a degree of risk to maintain their participation in daily activities. Alongside assessing and optimizing modifiable individual fall risk factors, programs need to support people to develop effective, realistic strategies to manage fall risk while maintaining engagement; to recognize when changes to their strategies are required; and to access further support as necessary. As in other groups, perhaps the focus of programs should move away from emphasizing fall reduction and instead move toward approaches that aim to maximize “safe mobility.”

The way forward is undoubtedly through collaboration: nationally, internationally, across disciplines, and with people with MS. A better understanding of this complex, individual, and multifactorial issue will assist in designing, evaluating, and implementing interventions to prevent or reduce falls for people with MS. 

## PRACTICE POINTS

- Falls are prevalent in people with MS and have significant negative consequences. Clinicians should ask about falls at all stages of the condition and refer for appropriate interventions in a timely manner.
- Falls are multifactorial and complex, and there are many, varied risk factors. The most reliable predictor of future falls is a history of falls.
- Interventions should target physiological risk factors (eg, balance and strength impairments), personal risk factors (eg, fear of falling, matching physical ability to the task) and environmental risk factors (eg, use of appropriate assistive devices).

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BY PAUL J. BETSCHART, DPM

### What Is Arthritis?

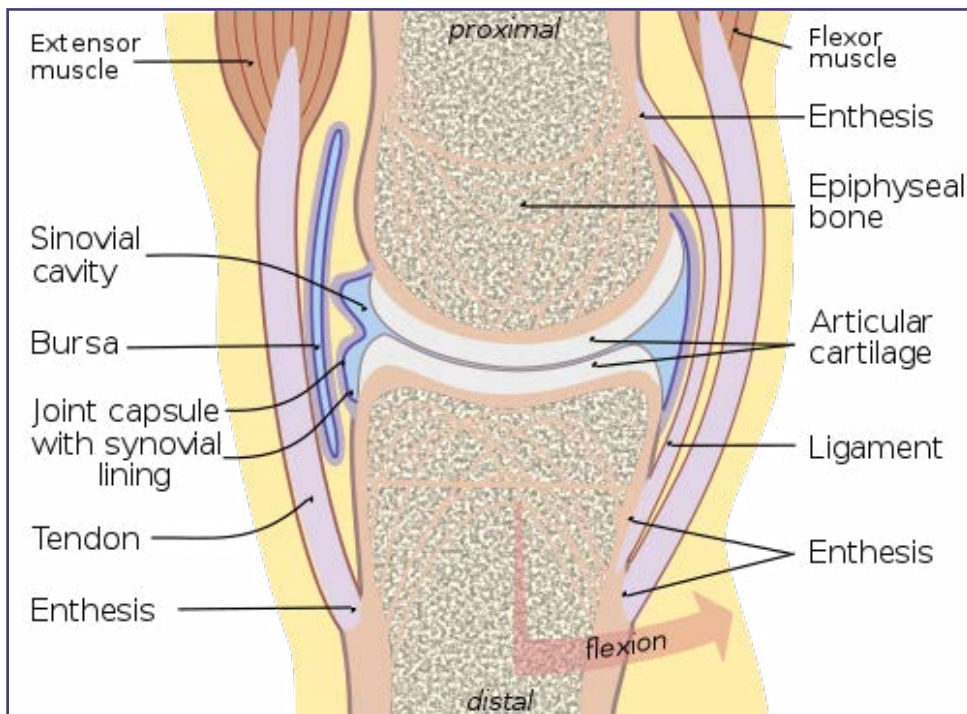
Arthritis is a medical term that describes inflammation of a joint; swelling and tenderness are common symptoms. Joints are areas where 2 different bones contact one another. Some joints allow for motion to occur and some do not. The freedom of movement ranges from none (skull sutures/bones in the head) to fully mobile (hip, shoulder) with varying ranges in between. Each foot has 33 joints, each with different degrees of freedom of motion. With so many joints and with the strain the feet have to withstand, the feet are commonly affected by arthritis.

### Types of Arthritis

There are 2 main types of arthritis that affect the human body: inflammatory arthritis and degenerative arthritis, also known as osteoarthritis. Examples of inflammatory arthritis are rheumatoid, psoriatic, gout, lyme, and septic arthritis, and ankylosing spondylitis.

With inflammatory arthritis, something triggers an immune response in the soft tissues surrounding the joint, called the joint capsule. If left unchecked, the immune response can lead to weakening of the supportive structures around the joint – the ligaments and tendons – which can lead to instability, dislocation, and deformity. Inflammatory arthritis rarely damages the cartilage directly. However, the inflammatory response it causes can disrupt the synovial tissue, which is the main source of nutritional support, and that disruption can lead to secondary degeneration.

Degenerative arthritis is caused by abnormal wear and tear of the articular cartilage, the smooth tissue that cushions the ends of most bones. Degenerative arthritis is age-related: it is a slow, progressive process, occurring over many years. Most joints in the body will show degenerative changes over time, typically viewed as



“normal aging.” However, abnormal alignments or traumatic events involving a joint, such as ankle sprains, can lead to earlier onset of degenerative changes and faster progression.

### How is arthritis diagnosed?

Arthritis is diagnosed through a combination of history, physical examination, imaging studies, and laboratory testing. Clues to the type of arthritis can be found in the history of the condition, for example, time of onset, speed of progression, location of symptoms, history of trauma, length of time stiffness, etc. Physical examination would reveal deformity, swelling, redness, increased temperature, and pain with palpation or motion. X-rays can identify deformities and provide radiographic clues to the type of arthritis, such as erosions, cysts, and joint space narrowing. Imaging – such as ultrasound, CT, or MRI – may also be needed for definitive diagnosis. Laboratory studies focus on identifying inflammatory and immune factors in the blood, as well as changes in the white

blood cell count. Joint fluid analysis can also be helpful at arriving at a diagnosis.

### How is arthritis treated?

Non-surgical treatment of arthritis focuses on three areas that work together:

**Inflammation reduction:** Inflammation can be reduced with oral medications, injectable medications, topical medications, and physical therapy modalities. Usually, some combination of modalities is used. Certain arthritic conditions, such as rheumatoid and psoriatic arthritis, are considered auto-immune conditions and may need to be treated with immune suppressive medications.

**Joint support and stabilization:** Joint support and stability are achieved with various orthopedic appliances, ranging from taping to rigid bracing. Selection of the appropriate appliance is based on clinical judgement and a patient's unique needs.

**Strengthening of surrounding musculature:**

*Continued on page 54*

Strengthening of the supporting musculature is achieved by employing specific exercises, commonly directed by a physical therapist or other health professional.

## Clinical Reality

The majority of arthritis patients that I see in clinical practice as a podiatrist have degenerative arthritis. Most are painfully aware of it, some are not.

While any joint of the foot can be affected, the great toe joint, ankle, and sub-talar joints (figure below) are the most commonly problematic. After ruling out other issues and arriving at the diagnosis, treatment can be initiated. As mentioned previously, degenerative arthritis commonly has a low-grade inflammatory component. Reducing this inflammation is the first step in treatment, typically an injection of anti-inflammatory medication directly into the involved joint is the fastest way to reduce joint inflammation. Fluoroscopy or ultrasound can be helpful for joint identification and needle guidance. A short series of 2-3 weekly injections is usually effective at reducing this inflammatory component. Combination therapy with oral and/or topical anti-inflammatories can also be used. CBD products, either orally ingested or topically applied can also be helpful at reducing symptoms.

Temporary immobilization of the affected joint using taping, bracing, or casting may be needed in some cases. Long-term stabilization of the involved joints is achieved using cus-

Temporary immobilization of the affected joint using taping, bracing, or casting may be needed in some cases. Long-term stabilization of the involved joints is achieved using custom-molded foot orthoses

tom-molded foot orthoses which are created using a mold of the patients' foot. With ankle involvement, ankle-foot orthoses (commonly called AFOs) may be needed.

Footwear is an important and commonly overlooked area to consider with arthritis patients. Areas to consider when selecting footwear for the arthritic patient are: accommodation of deformities, support and stability of the foot and lower extremity, and accommodation for orthoses and braces. Fortunately there are a number of manufacturers that make a variety of shoes that are appropriate for the arthritis patient. Propet, New Balance, Anodyne, Vionic, and Dr Comfort are some of the brands that we recommend. But please note, professional sizing and fitting is important for a successful result. As a podiatrist, I often refer my patients to a certified pedorthist for appropriate shoe-fitting.


Should symptoms persist after anti-inflammatory measures are used, physical therapy

modalities can be employed. Class 4 laser therapy is a newer modality that is very effective at reducing pain and inflammation. Applications of 10-20 minutes, 1-2 times a week for 3-4 weeks is a typical protocol. Other modalities that can be used include ultrasound, electrical stimulation, hydrotherapy, paraffin, and infrared.

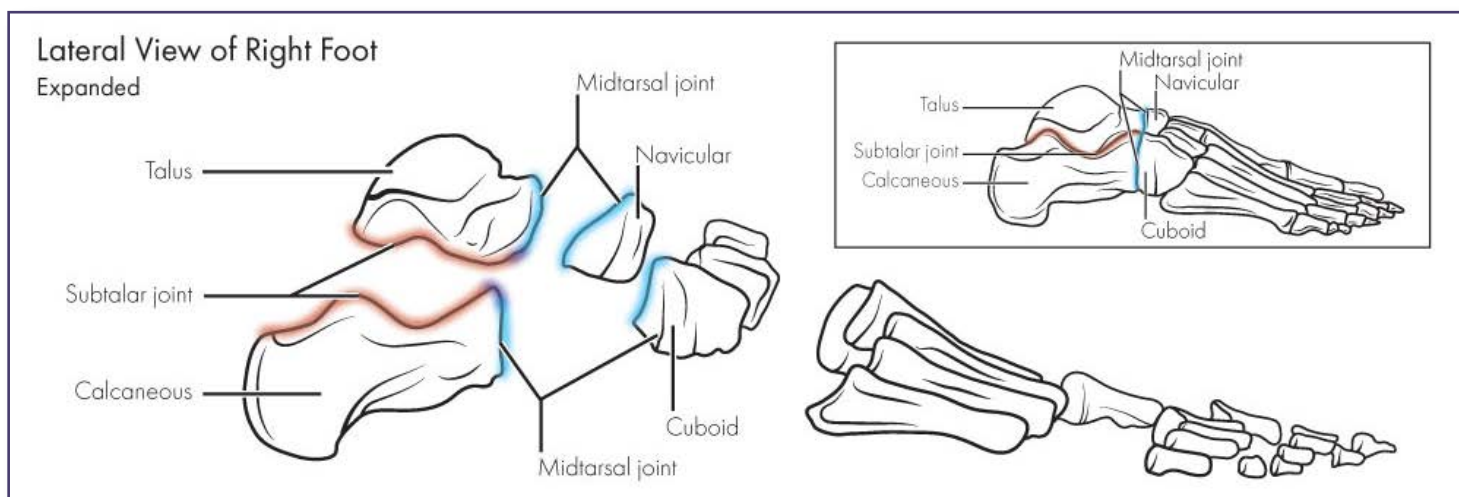
Rehabilitation can begin after the inflammatory response is under control. Exercises prescribed are based on the joints involved and other patient specific needs. Consultation with a physiatrist or physical therapist may be needed.

Inflammatory arthritis may be treated in a similar manner. Input from the patient's primary care doctor and rheumatologist should be sought for managing their medications, particularly for those on immune suppressants.

Anyone with persistent joint pain in their feet and legs should have an evaluation by a foot and ankle specialist right away. Like most medical conditions, early intervention is important to protect and preserve joint structure and function.

Anyone needing more information on arthritis the lower extremity is invited to contact me at my office in Danbury, CT, or visit our website for more information [www.advancedfootandanklecenter.com](http://www.advancedfootandanklecenter.com). 

*Paul J. Betschart, DPM, FACFAS, is a podiatrist in private practice in Danbury, Connecticut. A Fellow of the American College of Foot and Ankle Surgeons, his goal is to help his patients achieve optimal health from the ground up.*



Medical illustration by Chyna LaPorte for *Lower Extremity Review*.

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The Surestep Stabilizer is a device that provides mediolateral stability, as well as stabilizing the foot/ankle in the sagittal plane, facilitating clearance during swing phase for patients with dropfoot. With the carbon fiber insert on the posterior strut, the Stabilizer helps to bring the foot up as the leg swings across, but also helps to assist with deceleration of the foot after heel strike. This makes for a much more normal, natural gait.

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BALANCED!**



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Size	Child	Ladies	Mens	Height
XXXS	9-12			8mm, 13mm or 25mm
XXS	13-2			
XS	3-5			
SMALL		5.5-8.5	6-8	1/2", 3/4" or 1-1/4"
MEDIUM		9-11	8.5-10	
LARGE		11.5-13.5	10.5-13	
X-LARGE		14+	13.5+	



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# New & Noteworthy

Noteworthy products, association news, and market updates

## SURESTEP ORTHOTIC SOLUTIONS FOR ADULTS



Surestep, an innovator in pediatric orthotics for more than 20 years, now offers unique adult solutions. The Stabilizer is more than a preventive option for adults who experience stability and balance issues. It's a solution that restores confidence, proprioception, and function. With the risk of falling greatly reduced, patients are free to re-engage with day-to-day activities. The Gauntlet Series is a superior approach to traditional custom leather ankle support systems. Surestep's orthoses are fabricated to deliver flexible comfort coupled with control. The combination of soft and rigid plastics allows for 3 unique versions to optimally treat severe (acute), moderate, or mild (early stage) conditions. The Stirrup AFO is a custom ankle foot orthosis (AFO) that is designed to treat chronic conditions of the foot and ankle, especially for patients needing more ankle stability and hindfoot control.

### Surestep

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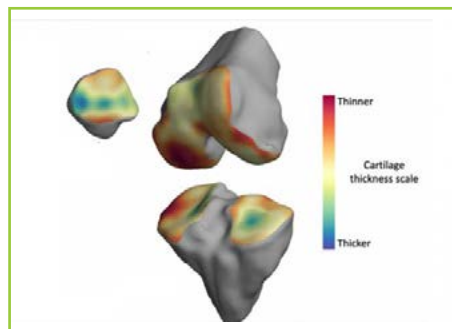
## IMPROVED MRI SCANS COULD AID IN DEVELOPMENT OF ARTHRITIS TREATMENTS

A team of engineers, radiologists, and physicians from the University of Cambridge have developed an algorithm that builds a 3D model

of an individual's knee joint to map where arthritis is affecting the knee. It then automatically creates 'change maps,' which not only tell researchers whether there have been significant changes but allow them to locate exactly where these are. This technique could boost efforts to develop and monitor new therapies for arthritis.

"We don't have a good way of detecting these tiny changes in the joint over time in order to see if treatments are having any effect," said James MacKay, MA, MB, BChir, MRCP, FRCR, PhD, from Cambridge's Department of Radiology. "In addition, if we're able to detect the early signs of cartilage breakdown in joints, it will help us understand the disease better, which could lead to new treatments for this painful condition."

The same team previously developed an algorithm to monitor subtle changes in arthritic joints in CT scans. Now, they are using similar techniques for MRI, which provides more complete information about the composition of tissue—not just information about the thickness of cartilage or bone. MRI is already widely used to diagnose joint problems, including arthritis, but manually labelling each image is time-consuming, and may be less accurate than automated or semi-automated techniques when detecting small changes over a period of months or years.



The thickness of the cartilage covering the end of each bone is color-coded, with red areas denoting thinner cartilage and green-blue areas denoting thicker cartilage. The technique helps locate where arthritis is affecting the joint over time. Image courtesy of University of Cambridge.

The technique MacKay and his colleagues from Cambridge's Department of Engineering developed, called 3D cartilage surface mapping (3D-CaSM), was able to pick up changes over 6 months that weren't detected using standard X-ray or MRI techniques.

The software is freely available to download and can be added to existing systems. MacKay said that the algorithm can easily be added to existing workflows and that the training process for radiologists is short and straightforward. To access the software, visit <https://mi.eng.cam.ac.uk/Main/StradView>.

## NERVEREVERSE NEUROPATHY SUPPORT



Free Life Labs' NerveReverse is designed to improve blood flow and reduce inflammation surrounding the nerves. This allows damaged nerves to return to a healthy state, eliminating those nagging symptoms such as numbness, burning, and tingling. The NerveReverse neuropathy starter pack includes a 180-count (90-day) supply of the neuropathy support formula and a 4 oz. jar of the fast-acting pain cream. It is packaged in a branded box complete with instructions. Also, for new wholesalers, buy 1 case get 1 free (1 case each maximum). This is a great way to get started if you are new to these products. The product is guaranteed to work in 90-days or your money back.

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## USC TO STUDY COMBINING 2 WALKING REHAB APPROACHES FOR STROKE SURVIVORS

Physical therapists could soon have something new in their toolbox to improve outcomes for survivors of stroke whose gait has been affected, thanks to a \$100,000 Magistro Family Foundation Research Grant awarded to a University of Southern California (USC) Division of Biokinesiology and Physical Ther-

apy research team, led by Kristan Leech, PhD, DPT, PT.

"The International Classification of Functioning, Health and Disability framework divides walking dysfunction into 2 domains: impaired walking patterns (e.g., kinematic deviations) and limited walking activity (eg, slow walking speeds)," Leech said. "Impaired walking patterns are typically addressed through biofeedback-based gait training that promotes intentional changes in voluntary movement. In contrast, the gold standard for improving limited walking activity is aerobic exercise intensity-based gait training."

In the new study, USC researchers, including co-investigators James Finley, PhD, and Carolee Winstein, PhD, PT, FAPTA, aim to better understand how combining the 2 approaches might improve physical therapy outcomes. The study will consist of 2 separate experiments. In the first experiment, the investigators will compare the short-term effects of feeding back 3 different features of how someone walks to understand better which gait biofeedback variable is the most effective in eliciting the greatest walking pattern movement. In the second experiment, researchers will test the capacity of survivors of stroke to make biofeedback-driven walking pattern changes at 3 different aerobic intensities (or speeds) of walking.



"If successful, this work stands to improve the current standard of care in gait rehabilitation post-stroke by improving the efficiency and efficacy of physical therapy interventions—ultimately reducing disability in this increasing population," Leech explained.

The study will take place over 2 years and will require 50 survivors of stroke to participate.

## EXTRA-WIDE DIABETIC WELLNESS AND COMFORT SOCK WP4



OS1st's WP4 Wellness Performance Socks are fabricated using nano-bamboo charcoal, and they are seamless, non-binding, and cushioned. Now, the same sock is available with 50% more stretch for an extra-wide fit; they are available in medical crew and no show. The extra-wide WP4 Wellness Performance Socks feature 4 zones of compression, from light compression at the seamless toes and ankle for comfort, to moderate compression at the arch for support and superior fit. The special contoured, nano-bamboo charcoal fibers create a cushioned footbed and heel areas to provide extra protection all while still being non-constricting. These socks keep feet dry and comfortable using micro-fiber nylon and OS1st's signature silver ion treatment, creating anti-microbial and moisture-wicking properties to prevent blisters and sock slipping, all important features for aiding with diabetes, sensitive feet, edema, and neuropathy.

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### AFOSR ADVANCES SCIENCE OF WOUND HEALING TECHNOLOGY

Ground-breaking research into cellular reprogramming, made possible in part with funding from the Air Force Research Laboratory's Air

Force Office of Scientific Research (AFOSR), is leading to technology that could heal wounds more than 5 times faster than the human body can heal naturally, vastly improving long-term healthcare outcomes for warfighters and veterans.

Indika Rajapakse, PhD, associate professor of computational medicine and bioinformatics and associate professor of mathematics at the University of Michigan, is researching ways to reprogram a person's own cells to heal wounds faster. To get high-resolution views inside live cells to better understand the wound healing process, Rajapakse received funding from the Defense University Research Instrumentation Program to purchase a live cell imaging microscope. The microscope also assists in gathering data for an algorithm that can mathematically identify when best to intervene in a cell's cycle to heal wounds; Rajapakse also was awarded a grant for research to improve this algorithm.

Cellular reprogramming is the process of taking one type of human cell, such as a skin cell, and reprogramming its genome so that it becomes a different kind of cell, such as a muscle cell, blood cell, neuron, or any other type of human cell. This is done using proteins called transcription factors. Transcription factors "turn on and off" various genes within cells to regulate activities such as cell division and growth, and cell migration and organization.

With the application of the right transcription factors, Rajapakse found that wounds healed more than 5 times faster than allowing



A live cell imaging system in the Rajapakse lab purchased with AFOSR-funded Defense University Research Instrumentation Program resources. Photo courtesy of Indika Rajapakse/University of Michigan.

the wounds to heal on their own. The next step is to figure out how best to apply them. The envisioned technology would act like a "spray-on" bandage, applying transcription factors directly to wounds. This method would convert exposed deep muscle cells into surface skin cells, which would mean a higher probability of successful healing than the current methods of skin grafting. Other potential challenge areas and medical applications include burn healing, skin grafts, organ transplants, etc.

### FITTERFIRST 12- AND 14- INCH SLANT BOARDS



Fitterfirst Slant Boards are effective stretching devices for performance enhancement, injury prevention, and rehabilitation. These adjustable incline boards are designed to target and stretch the calf, arch, hamstring, and hip muscles. They are well-suited for use in a clinic, club, or at home. The new 12-inch regular design, the SLANT12, features a 10-degree angle at the lowest setting for the BESTest Balance Evaluation System Test. For steeper angles suitable for athletes and larger foot sizes, use the larger 14-inch model, the SLANTL, which includes a built-in hand cutout for portability. Both models feature a non-slip top and bottom surface, and both fold flat. The 12-inch model adjusts to 10, 20, and 26 degrees, while the 14-inch model adjusts to 20, 30, and 40 degrees.

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## MFLEX FULL-BODY DEEP-TISSUE MUSCLE RELEASE TOOL



The MFLEX from Njoie is a full-body personal massage tool specifically designed to target the hard-to-reach trigger points most other massagers cannot. The MFLEX features an easily adjustable base that widens from 5.25" to 7.25" with the push of a button, providing versatility to users depending on the muscle groups they are targeting and each user's physical build. The interchangeable high and low heads help users make the transition from beginner to advanced, and a non-slip base with rubber tabs located at the bottom of either side of the device prevents it from sliding during use. The MFLEX directly aims to provide myofascial release, loosening up muscles, like the psoas, back, hamstrings, shoulders, neck, calves, and scapula, with precision. Its modular system with an intuitive design makes this the most customizable massager to keep you moving.

**Njoie**

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## NPS, PAS CAN CERTIFY THE MEDICAL NEED FOR DIABETIC SHOES IN LIMITED CIRCUMSTANCES

The Centers for Medicare & Medicaid Services (CMS) has recently provided guidance to the Durable Medical Equipment Medicare Administrative Contractors (DME MACs) that allows nurse practitioners (NPs) and physician assistants (PAs) to certify the medical need for diabetic shoes when all of the following

conditions are met:

1. The supervising physician has documented in the medical record that the patient is diabetic and has been, and continues to provide, the patient follow-up under a comprehensive management program of that condition; and,
2. The NP or PA certifies that the provision of the therapeutic shoes is part of the comprehensive treatment plan being provided to the patient; and,
3. The supervising physician must review and verify (sign and date) all of the NP or PA notes in the medical record pertaining to the provision of the therapeutic shoes and inserts, acknowledging their agreement with the actions of the NP or PA.

## IFAST DYNAMIC ANKLE STABILIZER



The IFAST® dynamic ankle stabilizer was developed with the body in mind, moving the way athletes move and protecting the way the body protects. It fits easily inside any shoe. Incorporated into the IFAST is a synthetic ligament. Using specially selected materials, the tension system behaves like the ligaments in the body; an adjustable tension cord allows for a customizable level of support. An upper and lower cuff secures the device to the ankle. By using a material slightly sturdier than the tension system, these cuffs act like the bone and keep all motion and protection focused on the ankle joint. The compression sleeve acts as the skin, surrounding the ankle joint, keeping

it warm and mobile. This creates precise and total custom ankle protection, allowing performance at the highest levels, only intervening before athletes move past the end range of motion.

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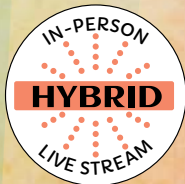
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## DJO ACQUIRES TRILLIANT SURGICAL

DJO, LLC, Lewisville, TX, announced the acquisition of Trilliant Surgical, Houston, TX, a national provider of foot and ankle orthopedic implants. The acquisition supports DJO's focused expansion into the adjacent high-growth \$1 billion US foot and ankle market. Financial details of the transaction were not disclosed.

## ATI LAUNCHES SPECIALIZED LIMB LOSS TREATMENT PROGRAM

ATI Physical Therapy (ATI), Bolingbrook, IL, has launched new limb loss specialty centers that expand the use of outpatient physical therapy (PT) and creates a stronger care continuum for patients who are scheduled to undergo limb loss surgery or have experienced limb loss. The specialty program and centers of excellence were developed in partnership with Hanger Clinic, Austin, TX. ATI's physical and occupational therapists will join physicians and prosthetists on the forefront of each patient's rehabilitation journey, providing activity-based treatment designed to help patients heal faster, acclimate to their new prostheses, and maintain quality of life. The pilot initially launched in Michigan with 15 ATI Centers of Excellence. Now, the program is available in more than 70 ATI specialty centers across Michigan, Illinois, and Indiana with future plans to expand.



# 2021

## ANNUAL MEETING OF THE



THE CONSORTIUM OF  
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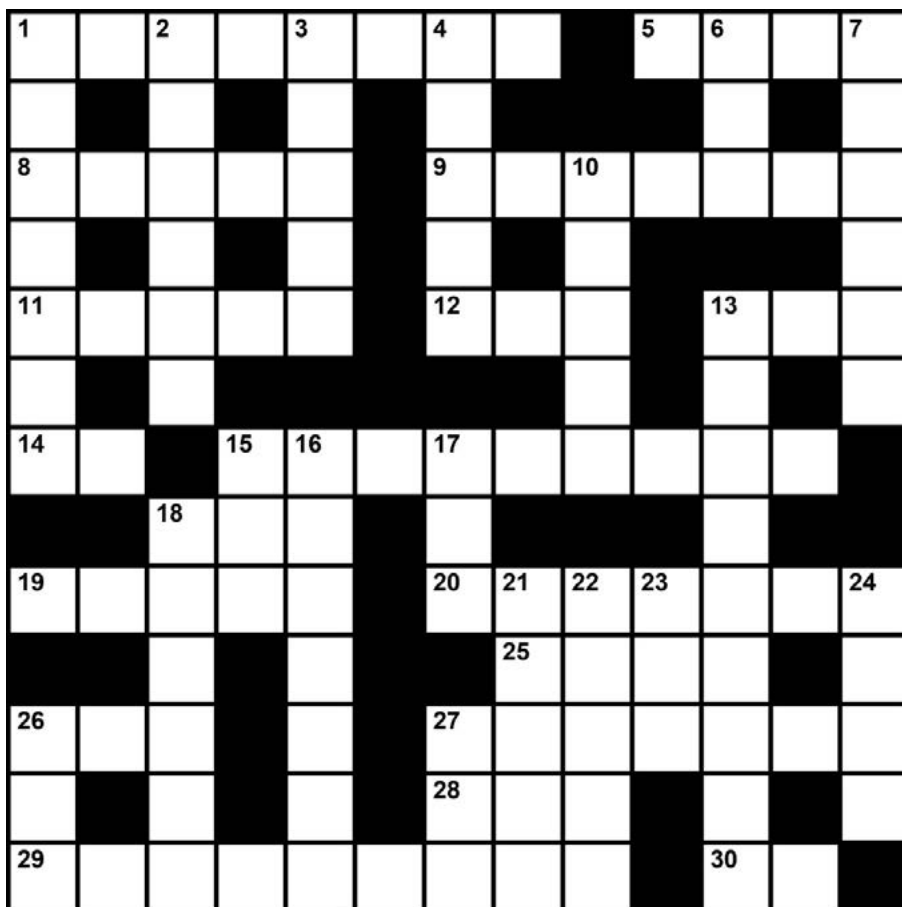
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the largest North American  
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professionals and  
researchers engaged  
in MS care.



## 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](http://lermagazine.com).



### ACROSS

- 1 Study of motion and forces connected with it
- 5 Manner of walking: sometimes suggested as the sixth sign of health
- 8 Bundle of axons
- 9 The N in CNS
- 11 The S in GAS
- 12 Savings account, abbr.
- 13 African antelope
- 14 International system of units
- 15 Muscles or glands that respond to a stimulus
- 18 Long, long \_\_\_\_
- 19 The ability to regulate or direct the mechanisms essential for movement, goes with 27 across
- 20 Foot bones
- 25 Food intake regime
- 26 Highest amount, abbr.
- 27 See 19 across
- 28 Part of some Internet addresses
- 29 Toe bones
- 30 Storage medium for xrays, etc.

### DOWN

- 1 Movement that is a response to a stimulus
- 2 Limited in size or scope
- 3 Motif
- 4 \_\_\_\_ forms: three small foot bones
- 6 Ankle-foot-orthosis, abbr.
- 7 Aggregate of cells with similar functions
- 10 Respond
- 13 Relating to the aged
- 15 Self image
- 16 Fixed method of achieving a result
- 17 Consume
- 18 Friedrich's \_\_\_\_
- 21 Idolize
- 22 Circular shapes
- 23 Congeal
- 24 Bottom of a foot
- 26 Chart
- 27 Part of a gearwheel

### 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](http://www.themecrosswords.com)

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