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LOWER EXTREMITY REVIEW
February 18 / volume 10 / number 2

ASSESSING LIMB LENGTH DISCREPANCY

The impact of LLD on muscles, bones, joints and movements

Computer-assisted gait assessment can aid in detecting and addressing LLD

DIABETIC FOOT

PROMOTING ADHERENCE WITH OFFLOADING DEVICES

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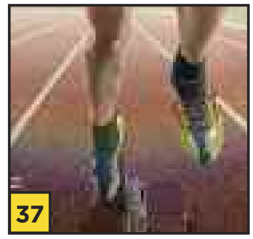

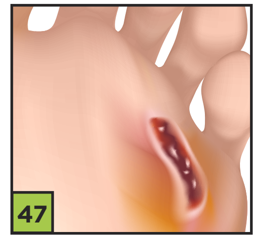

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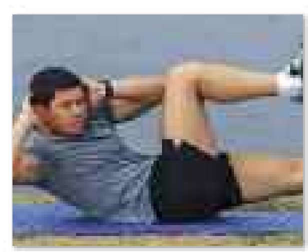

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Strengthening the Interprofessional Approach to Fall Prevention

Elizabeth W. Peterson, PhD, OTR/L, FAOTA

Mariana Wingood, DPT, PT, GCS, CEEAA

Health care professionals who work with older adults are all too familiar with the devastating sequelae of falls, including injury and fear of falling that can lead to activity restriction and further risk of falls. Most worrisome is that death rates from falls have doubled between 2000 and 2014,[1] which highlights the importance of sustaining existing fall prevention efforts, and of building new ones. The statistics and complexity of fall prevention demonstrate a clear need for interprofessional approaches to reduce fall risk among older adults.

Key resources for clinically-based, interprofessional fall prevention efforts in the United States are the American and British Geriatric Societies (AGS/BGS) fall prevention guideline[2] and the Centers for Disease Control and Prevention's Stopping Elderly Accidents, Deaths, and Injuries (STEADI) initiative.[3] Further imperatives for interprofessional approaches are the US patient safety movement and the Patient Protection and Affordable Care Act, which focus on the value and quality of medical services.[4,5]

The newly established National Council on Fall Risk Awareness and Prevention (NCFRAP) represents an effort to build on these initiatives. This interprofessional group includes10 volunteering health care clinicians and researchers who collectively have expertise in balance assessment and intervention, and fall prevention. Members include an MD and assistant professor at Johns Hopkins University School of Medicine; a PhD, director of surgery and director of clinical research at Baylor College of Medicine; a PhD and physical therapist who is an associate professor at Upstate Medical University; a PhD in biomechanics; as well as the two writers of this editorial.

Initial Council meetings have yielded clear goals, including the creation of compendia to STEADI that support diverse health care providers in their efforts to screen for modifiable, lower extremity fall risk factors and make appropriate referrals to address identified risk factors. A review of the literature to inform the development of these resources is underway, and results from the Council's efforts will be disseminated through a variety of channels ranging from conference presentations and publications, to consumer publications and social media outreach.

The result of the Council's near and long-term work will help secure the standing of a strong segment of LER's readership -- podiatrists, physical and occupational therapists, pedorthists, and orthotists – as central in the identification and treatment of fall risk in our senior population. The Council's work highlights the benefit of drawing from evidence-based fall prevention resources and working within one's sphere of influence to address the formidable problem of falls.

Each member of the health care community serving older adults has a unique opportunity to build upon the attention to both fall prevention and interprofessional collaborative practice that is occurring nationally. Each healthcare professional brings value to fall prevention, and, through interprofessional efforts, we can amplify that value.

Elizabeth W. Peterson is clinical professor and director of professional education in the department of occupational therapy at the University of Illinois at Chicago.

Mariana Wingood is a physical therapist at the University of Vermont Medical Center in Burlington, VT.

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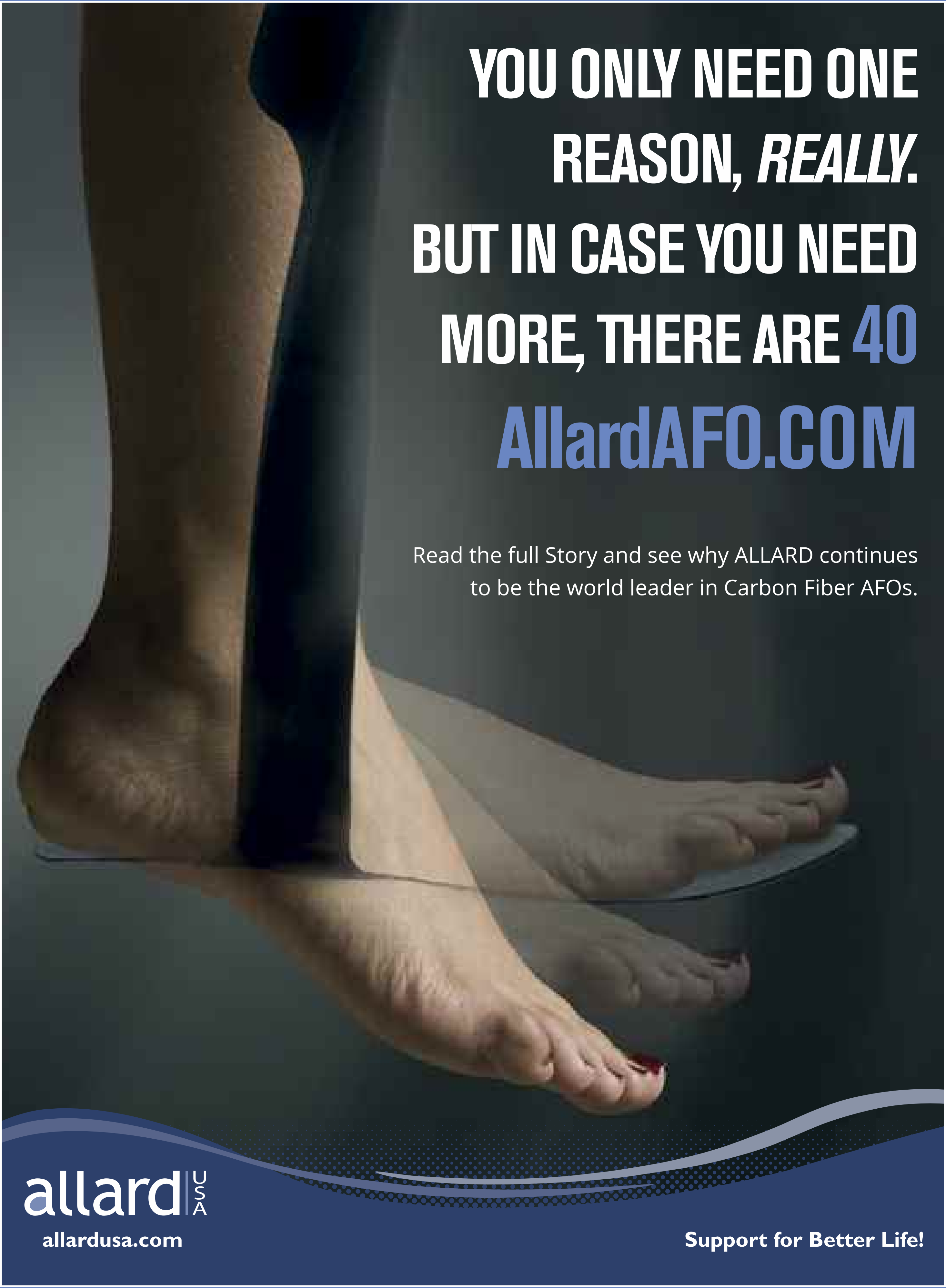
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Exercising arms improves post-stroke walking

Canadian researchers have demonstrated that that arm exercises—specifically, cycling the arms—improves post-stroke gait. The authors said this is the first study to test the effect of arm training on post-stroke leg function, even years after the event. The results appear in the *Journal of Neurophysiology*.

Researchers recruited 19 patients, age 57 to 87 years of age, who were 7 months to 17 years post-chronic stroke. Patients underwent 30-minute sessions of arm cycling training at a moderate intensity, 3 times a week over the course of 5 weeks. Their physical abilities were measured at baseline and after arm training using the Six-minute Walk Test (6MWT), Timed 10-meter Walk Test (10MWT), the Timed Up and Go (TUG) test, and the Berg Balance Scale (BBS). In addition to electromyography testing, stretch reflexes were tested in the lower legs and wrists during arm cycling and walking tests.

Significant improvement was seen in the first 2 of these 4 outcome measures. Participants realized an 8.5% increase in the 6MWT, from an average of 245.1 m to 266.1 m, compared with the 7.4-m minimal detec02.18 change for patients after stroke. Participants decreased the time to perform the TUG test by 28.9%, from 37.3 s to 26.5 s, which is greater than the 2.9 s minimal detec02.18 change for patients after stroke.

The 10MWT showed a lesser degree of improvement. Participants reduced their time by 15.1%, from 24.5 s to 20.8 s, which is 3.7 s less than the minimal detec02.18 change for patients after stroke. Although BBS scores increased from 41.5 to 43.9, this change was slightly less than the minimal detec02.18 change of 2.5 for patients after stroke.

Furthermore, subjects' arms showed increased muscle activity and less muscle tightness after arm cycling training.

Prior tests on similar populations have involved both leg and arm cycling, with positive results. This study now demonstrates interlimb connectivity of the arms and legs, and that arm training contributed to improvements that were experienced in combined arm-and-leg training.

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"Arm cycling training activated interlimb networks that contribute to the coordination of rhythmic walking," the researchers wrote. "Although improvements in walking may not be as robust as those from other training modalities, they do highlight the integral role that training the arms can have on rehabilitation of human locomotion."

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TJA patients discharged home alone do well

Patients who live alone had a safe and manageable recovery when discharged directly home after total joint arthroplasty (TJA), according to a prospective study published in *The Journal of Bone & Joint Surgery*.

A majority of institutions routinely discharge patients, especially those living alone, to an inpatient rehabilitation facility following TJA. The rationale is that patients cannot be expected to safely convalesce at home without assistance. The results of this study challenge that standard protocol of admitting these patients to inpatient rehabilitation prior to returning home—a model that reduces medical costs and provides no indication of an increase in the rate of complications.

The prospective study examined 769 patients who underwent primary, unilateral total hip arthroplasty or total knee arthroplasty over an 8-month period. Of this cohort, 138 patients lived alone and 631 patients lived with someone else. Patients living alone more commonly stayed an additional night in the hospital and used more home health services.

No increases in complications or unplanned clinical events were found for patients living alone compared with those living with someone else. Furthermore, no significant differences in functional outcomes or pain relief were detected, and satisfaction scores were equivalent after 90 days. As long as 6 months after surgery, no significant differences were found in scores for joint functioning and quality of life. Nearly 90% of patients living alone said they would choose to be discharged home again. However, patients living alone did report more problems attending to personal hygiene.

Source

Fleischman AN, Austin MS, Purtill JJ, et al. Patients living alone can be safely discharged directly home after total joint arthroplasty: A prospective cohort study. J Bone Joint Surg Am. 2018;100(2):99-106.

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Researchers target prevention of posttraumatic osteoarthritis


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Reducing oxidative stress in mitochondria shortly after joint injury may prevent posttraumatic osteoarthritis (PTOA), according to a study published in Science Translational Journal. This discovery is compelling because young, active patients are more likely than older patients to experience these injuries, yet are not good candidates for joint replacement, given their young age.

Although some cartilage cells die upon impact in a joint injury, further cartilage cell death occurs in the 48 hours post-injury. Researchers sought to interrupt this cell destruction early in the process by "inhibiting mitochondrial metabolism with amobarbital, and boosting antioxidants in the chondrocytes with N-acetylcysteine (NAC)." Using a porcine model, which is well-suited to human-like surgical techniques and has anatomic similarities to the human ankle, researchers treated intra-articular fractures with an antioxidant or an inhibitor of the mitochondrial electron transport chain.

"We demonstrated that the PTOA that occurs in an ankle after a severe injury can be significantly blunted by inhibiting mitochondrial metabolism or adding key antioxidants immediately after injury," says the study's lead author, Mitchell Coleman, PhD, research assistant professor of orthopedics and rehabilitation at the University of Iowa Carver College of Medicine. "These treatments were only given twice, once right after injury and once a week later. No chronic therapy was used. Our data suggests that there might be a way to treat people acutely after they break their ankle to prevent PTOA." ler

Source

Coleman MC, Goetz JE, Brouillette MJ, el al. Targeting mitochondrial responses to intra-articular fracture to prevent posttraumatic osteoarthritis. Science Transl Med. 2018;10(427): pii: eaan5372.

Core weakness may lead to low back pain in runners

Deep core-muscle weakness in runners leads to compensation strategies that increase pressure and loading on the spine, which may increase the risk of low back pain, a new analysis demonstrates.

Study author Ajit Chaudhari, PhD, FACSM, professor of physical therapy at The Ohio State University, notes that, from the clinical perspective, there's long been a sense of a relationship between core strength and back problems. This study, published in the *Journal of Biomechanics*, provides preliminary biomechanical evidence to support that idea, he says.

Using motion capture and force plates to collect data on 8 healthy participants as they jogged around a track, Chaudhari created responsive computerized models of each participant's musculature. He then isolated and weakened particular muscles for the individual models, and looked at how the model compensated for those changes. The simulation program, developed in 2016 by Chaudhari and first author Margaret Raabe, PhD, is designed to find the most efficient mechanical solution that would maintain the same running form.

"The question we were asking is, what if the deep core muscles were weak, but the person wanted to run the exact same way?" Chaudhari says. "What other muscles would have to compensate to keep the same running kinematics?"

Through the simulations, Chaudhari found that superficial core muscles tended to be recruited to compensate for deep-core weakness. Those muscles are farther from the spine, which means they pull on the vertebrae from farther away, he says. That increases pressure on the spine.

When all deep core muscles were weak, spinal loading increased 15% on the L1 vertebra and 8% on L2 vertebra, according to the simulation. When only the deep muscles of the erector spinae, which extend up the spine, were weakened, the spinal loading increased 11% on the L1 vertebra and 6% on the L2 vertebra.

"We don't have lot of data to know how much loading is a safe amount," Chaudhari says, "but we know it can cause damage to the spine."

Moreover, superficial core muscles that are seen to compensate for deep-core weakness become fatigued faster, he says. "It could mean that running form would change faster," Chaudhari says.

However, because the simulation was designed to maintain the running form and kinematics of each subject, researchers were

unable to look for those potential changes.

The findings confirmed what clinicians observe about low back pain, says Michael Fredericson, MD, professor of orthopedic surgery at the Stanford University Medical Center: "For a back problem these days, you're going to get some core exercises."

Fredericson stressed that, because this study was based on computer modeling, it can't provide complete evidence of the relationship. "It's a way to give you an idea if that type of modeling makes sense theoretically, and if it does, it gives you the evidence to go ahead with a more clinical study."

Chaudhari agrees, noting that this analysis was just an initial step, and that clinical work will follow. "The next step is to fatigue people's muscles and see how they respond," he says.

If core fatigue and subsequent weakness lead to changes in running kinematics that are harmful, which the simulation didn't look at, that may be an indication that maintaining form is a good way to prevent pain or injury, he says. If, however, kinematics does not change, the emphasis may need to be on developing strength to prevent fatigue.

"We're looking to see what we should be using to train people going forward," Chaudhari says.

Source:
Raabe ME, Chaudhari AMW. Biomechanical consequences of running with deep core muscle weakness. J Biomech. 2018;67:98-105.

Group urges training exercises to prevent ACL injury

Athletic trainers and healthcare professionals have a fresh set of recommendations to help prevent noncontact and indirect contact anterior cruciate ligament (ACL) injuries in athletes and physically active people. The position statement, "Prevention of Anterior Cruciate Ligament Injury," from the National Athletic Trainers' Association (NATA)," was published in the *Journal of Athletic Training*.

In general, training programs that include a minimum of 3 of the 5 exercise categories (strength, plyometrics, agility, balance, and flexibility) along with feedback regarding technique, are recommended, in addition to a multicomponent injury-prevention training program. These training programs can help improve balance, lower-extremity strength and power, biomechanics, and functional performance measures.

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Given the variability among successful training programs and exercise groups to prevent ACL injury, the position statement offers general guidelines, rather than specifics, regarding the organization and types of exercise to include in multicomponent training programs.

The recommendations also call for injury-prevention training exercises performed at increasing intensity levels that are challenging and allow for excellent movement quality and technique. In addition, the position statement recommends that multicomponent training programs be performed during preseason and 2 or 3 times a week in-season, and should be continued from season to season to maintain benefits achieved.

Skilled individuals, such as athletic trainers, should supervise the training programs, providing feedback on technique and offering correction as appropriate. NATA also recommends that multicomponent training programs be implemented as a warm-up or as part of a comprehensive strength and conditioning program. In addition, the association recommends multicomponent preventive training program for all participants in sports and physical activity.

"Preventing ACL injuries during sport and physical activity may dramatically decrease medical costs and long-term disability," says lead author Darin Padua, PhD, ATC, director of the Sports Medicine Research Laboratory at the University of North Carolina at Chapel Hill. "Working with athletic trainers, physicians, and other healthcare and fitness professionals will help ensure athletes and those who are physically active are benefiting from injury-prevention training programs with proper technique and education."

Source
Padua DA, DiStefano LJ, Hewett TE, et al. National Athletic Trainers' Association position statement: prevention of anterior cruciate ligament injury. J Athl Train. 2018;53(1):5-19.

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ASSESSING LIMB LENGTH DISCREPANCY

Leg-length discrepancy and its sequelae are best considered a syndrome affecting many regions of the body through the closed kinetic chain. Most cases require comprehensive, cross-disciplinary treatment. The authors present a novel scoring system for diagnosis.

By Jay Segel, DPM; Susan Sanford, PT, L.Ac, C.SMA; Sally Crawford, MS; and Lori Yarrow, DC, BPE

Podiatrists, chiropractors, physical therapists, and athletic trainers are often the first healthcare practitioners to detect leg-length discrepancy (LLD, also known as limb-length discrepancy or short-limb syndrome). If the presenting complaint is not where the primary dysfunction is found (for example, knee pain as a result of faulty foot biomechanics), creating a treatment plan is an interesting clinical challenge, especially in a multidisciplinary setting.

Healthcare practitioners are caught in a conundrum, because different professions might use a variety of criteria for testing, communicating about, and treating a patient's condition, thus creating inconsistencies in diagnosis and management. Across professions, there may be debate about whether length discrepancy is a cause or an effect. This is a classic chicken-or-egg cycle encompassing a variety of closed-chain, biomechanical dysfunctions that result in pathology.

In response to inconsistencies we have witnessed across many professions regarding limb length pathology, we aim to provide context and clarity about LLD in this article by 1) redefining and creating universal terminology and 2) introducing a clinical assessment tool, the Sanford Symmetry Scale© (page 26) that can be used across professions.

Categories of limb-length discrepancy

Patients who have LLD are first categorized by type and chronicity:

Type. The 3 types of LLD are outlined in Table 1. It is important for the practitioner to resist assigning a single type of LLD to a patient because each type may be a cause or an effect, and the 3 types are not mutually exclusive; for example, a person might have an anatomical LLD with a functional component.

Chronicity. Is the LLD acute or chronic? The treatment plan (exercise, manual therapy, heel lift, orthotic, spinal alignment), the rate at which treatment is introduced, and the prognosis are vastly different, for example, for a patient who has acute LLD postoperatively and one who has chronic LLD resulting from a congenital defect.

Central role of the closed kinetic chain

Regardless of the cause of an LLD, examination of, and a treatment protocol that addresses, the entire closed kinetic chain is essential. Without a complete picture, background, and context, a practitioner may be unable to fully comprehend, or communicate, the sequelae of problems. This is a critical component in 1) developing a multifocal treatment plan that considers the ability to tolerate correction and 2) understanding the role played by the altered neuro-musculoskeletal system, before and after intervention.

Although we agree that distinctions among structural, postural, and dynamic types of LLD are relevant, we do not agree that structural and postural LLD are mutually exclusive or that there are only 2 types of LLD, and we do not agree with the general consensus to indiscriminately treat all 3 types of patients with a heel lift. The closed kinetic chain is complex and unique to each patient, and no definitive formula fits every patient's primary dysfunction or neuro-musculoskeletal compensation. We also recognize that structural, postural, and dynamic types of LLD are, as noted, not mutually exclusive.

It is the complex and unique closed kinetic chain of each patient—whether it was the cause or result of the LLD—that draws attention to other clinical variables:

- Physiological environment (age, neural plasticity, comorbidities, activity level, and compliance)
- Length of time that the patient's neuro-musculoskeletal system has compensated for (perhaps adapted to) the LLD.

It is critical that the practitioner investigate all of these variables, for each patient, and design a treatment plan unique to each one's LLD, compensation, comorbidities, age, and lifestyle.

Understanding limb-length compensation

We encourage you to pay as much attention to any abnormal compensation pattern as you do to the LLD itself. It is well documented that abnormal biomechanics, such as you would find in a compensatory pattern, can result in vibratory forces and microtrauma along the closed kinetic chain (Figure 1). The spinal facet; hip, knee, ankle and foot joints; and their associated muscles may suffer repetitive microtrauma resulting in sprain, strain, or degenerative joint disease. By addressing compensatory neuro-musculoskeletal function, you may be able to assist the patient with a cascade of dysfunction through the musculoskeletal system.

We also encourage you to make use of gait assessment technology to quantify, document, and monitor patients' progress. Application of reproducible, documented metrics is essential to communicate effectively within a multidisciplinary system that is committed to practicing evidence-based medicine.

Table 1. 3 types of leg-length discrepancy

Anatomical/Structural/True	Functional/Postural/Apparent	Functioning/Dynamic
A measured difference in leg length resulting from inequalities in bony/osseous structure.*	Unilateral asymmetry of the lower extremity without concomitant shortening of osseous components of the lower limb*	A difference in weight-bearing pressure of both feet during dynamic activities
May be the result of congenital growth abnormality; disruption in growth-plate integrity; knee-flexion contracture; postoperative course of total knee or hip replacement; or severe arthritis of hip, knee, or ankle	A difference in weight-bearing pressures of both feet during static standing, resulting from postural asymmetry or multiple asymmetries along the kinetic chain	May present in the absence of structural or functional LLD
	Structural bone length is confirmed equal upon measurement	May result from 1) weakness or abnormal length of a muscle or 2) joint dysfunction presenting during motion or any phase of the gait cycle

*Source: Leg length discrepancy. Physiopedia. https://www.physio-pedia.com/Leg_Length_Discrepancy. Accessed February 8, 2018.

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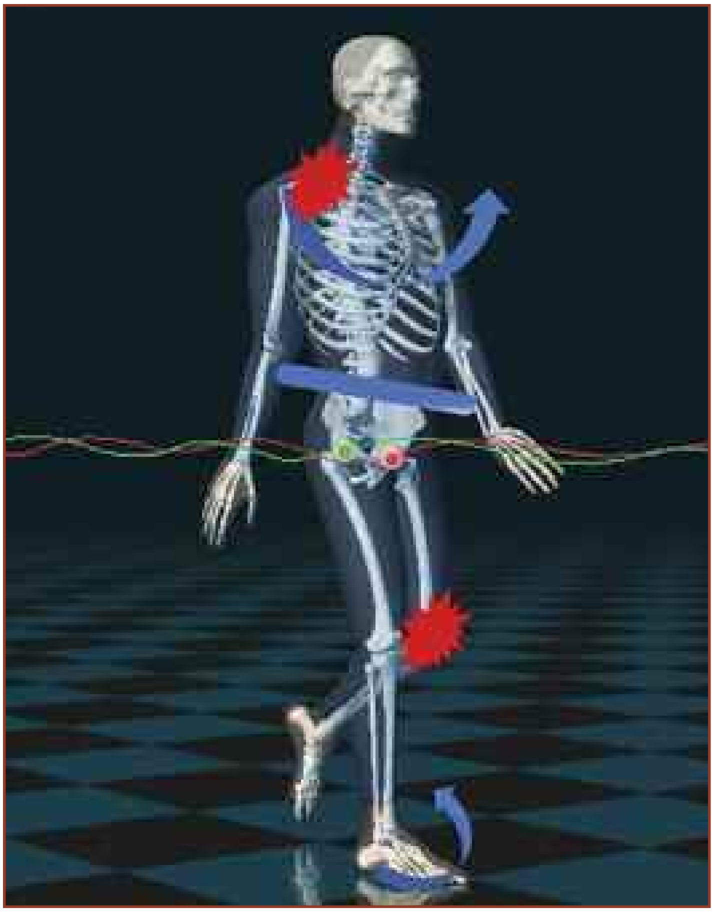

Figure 1. The closed kinetic chain at impact. The closed kinetic chain is represented using computerized-assisted gait assessment (CAGA) technology to demonstrate intrinsic relationships occurring at impact.

Figure 2. Components of the closed kinetic chain, as external forces are applied

Clinical approach to the patient with LLD

To begin piecing together the puzzle of LLD pathology, begin by taking a comprehensive history and performing a comprehensive physical exam:

- Know your patient. Understand the multiple roles in his (or her) life: Is he an athlete? A senior? A sitting worker, chronic pain sufferer, weekend warrior, or standing worker?
- Discover his goals. Does he want to run a marathon? Dance at a wedding? Walk more to lose weight, control blood pressure, or manage diabetes? Or just sleep through the night?
- Communicate, educate, and set realistic timelines. Avoid dumbing-down your explanations. To accommodate visual and auditory learners, use pictures as well as providing explanations. Let the patient know that a return to balance is a gradual, sometimes slow, process. Emphasize that ideal balance might not be achievable; the goal should be improvement, not perfect balance.
- Avoid the silver bullet. A patient's biomechanical and pathological condition is rarely a single diagnosis and is rarely due to a single factor. For example, a knee injury incurred in young adulthood may lead to degenerative changes and contralateral compensation through the hip, knee, and foot, presenting as plantar fasciitis.

With these 4 core elements of the initial approach to the patient and his problem, the history and examination will be more productive.

Taking the history

Patients tend to not understand all of the factors that have contributed to, and continue to be related to, their LLD. Ask the patient to recount family history (including congenital disorders), trauma, surgery, chronic conditions, and ongoing repetitive stress that he might not realize has contributed to his musculoskeletal imbalance. Some of the most common historical indicators of LLD include trauma, fracture of the growth plate, scoliosis, joint replacement, severe arthritis of a weight-bearing joint, surgery of a weight-bearing bone or joint, congenital hip dysplasia, and any other congenital anomaly of a weight-bearing joint or bone.

We have found that demonstrating the closed kinetic chain to the patient is a useful educational tool while discussing the possible sources of postural asymmetry (Figure 2). For example: Have the patient stand and externally rotate his left hip so that the left foot is abducted and the whole left column has been shortened. Then, explain that, although it appears that the leg is short, the bones themselves have not changed; rather, the LLD is the result of postural and soft-tissue imbalance, and that, in rotating the hip, he has altered the relationship between muscle groups and bony alignment without changing the actual length of bones.

This type of demonstration enhances history-taking and helps the patient understand the impact of his ADL (Figure 3), posture at

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work, sitting position, and movements during sports. When you assess and address a set of concerns, it helps to not only to know the history of when the problem started but also the history of activities seemingly unrelated to the problem. For example, knee pain in a soccer player may require strengthening, change in technique, recovery routine, and exercise–dose response, in addition to addressing the LLD. Keep in mind that it is easier to see improvements when a patient participates in a sport than when the complaint is related to ADL, which makes it more challenging to uncover the core of the problem and then measure progress.

Figure 3. Effects of activities of daily living. Activities such as carrying a heavy bag on 1 shoulder, reaching and lifting repetitively, or pushing work-related materials can result in musculoskeletal imbalance and a functional limb-length discrepancy. Asking questions about activities of daily living, apart from sport or work tasks, is of great importance and should be a focus during the first visit or session, at which time a baseline, objective report is essential.

Physical examination

Once you have taken a comprehensive history, there are certain findings on the physical exam that should lead you to suspect an LLD and, possibly, a compensatory pattern, such as 1 pants leg shorter than the other (ask if 1 leg of the pants is shortened more than the other when visiting a tailor) and a unilateral foot-centric abnormality (e.g., bunion, bone spurs, keratosis, and arch drop).

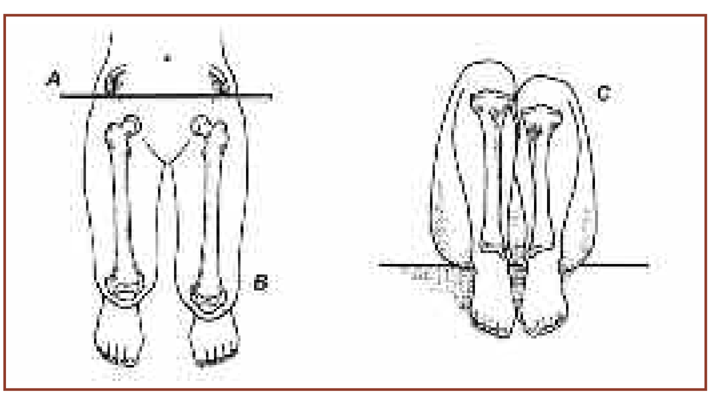

Figure 4. Webster-Barstow maneuver test[4] (Allis test). With the patient supine with the heels off the end of the exam table, the examiner holds the patient's feet together with hips and knees bent. The examiner places his or her thumbs over the medial malleoli while providing traction and instructs the patient to raise his hips upward and then return them to the starting position. Any difference in the final position of the thumbs indicates asymmetry.

Other common findings on the short leg side include a unilateral, relatively tight or short Achilles tendon and tender plantar fasciitis. You may also find palpable bone spurs and/or bony hypertrophy proximal to the medial longitudinal arch on the medial dorsal surface and imbalance in strength and laxity in tendon groups.

Screening for LLD

We recommend screening all patients who have a lower-limb complaint for LLD. This is essential when the complaint is unilateral or includes low back pain or a spine-related disorder, such as radiculopathy. Proceed as follows, with the patient in these positions:

Supine. Perform a bridge test (the Weber-Barstow maneuver test (Figure 4,[4]); also known as the Allis sign); a supine to long sit test; and a Squish test of the sacroiliac joint. Evaluate the anterior superior iliac spine for asymmetry.

Standing. Evaluate for head tilt, shoulder drop, tibial tubercle height asymmetry, anterior superior iliac spine, posterior superior iliac spine, trochanter height, asymmetric arch drop, and asymmetric pronation or foot abduction (Figure 5).

Seated. Examine the medial malleoli, palpating for a specific, anatomically pronounced area on both prominences. Compare the medial malleoli bilaterally.

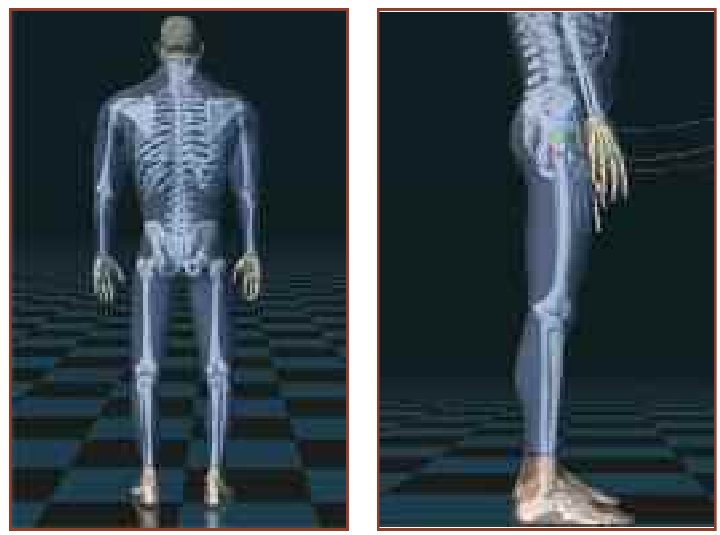

Figure 5. CAGA lead placement. Leads in place are shown as blue, green, and red marks.

Using the Sanford Symmetry Scale

In this article, we present the comprehensive Sanford Symmetry Scale (page 26) as a guideline for the diagnosis and treatment of LLD. The Scale can be used to identify all 3 types of LLD and causative findings, using accepted clinical tests for a comprehensive musculoskeletal evaluation during the initial examination and reassessments. A score is given for each test; the higher the cumulative score, the greater the asymmetry.

The purpose of the Scale is to establish a baseline and identify changes after treatments and interventions. The Scale is not intended to provide a threshold to determine the presence or absence of LLD. (The authors intend to submit the Sanford Symmetry Scale for review, validation, and evaluation.) After identification of an LLD using the Scale, a practitioner should use clinical judgment to arrive at a final diagnosis and establish treatment priorities over the short and long term.

Continued on page 22

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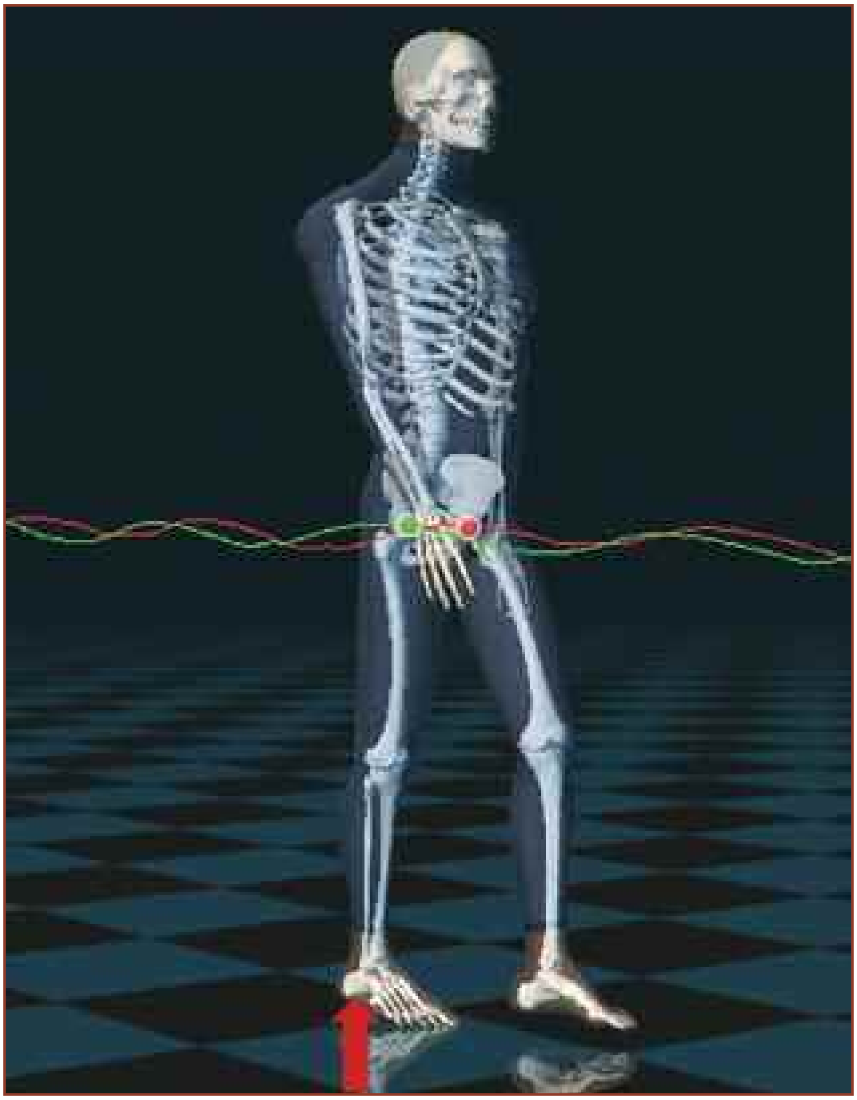

Figure 6. Early heel off visualized using CAGA

As corrective techniques are introduced, the Sanford Symmetry Scale can be used to monitor objective changes. Because the full clinical picture may reveal itself only as the patient progresses through a treatment plan, it is important to perform all of the tests on the Sanford Symmetry Scale during each reassessment and document a changing or stable score along with the patient's subjective report.

To use the Sanford Symmetry Scale, it is essential to examine the patient in 5 positions: static prone, supine, sitting, standing, and during gait. The baseline exam and reassessment must include all of these positions. Examples: A patient's right leg might be internally rotated in the supine position, which will functionally lengthen the limb when walking; or, an externally rotated foot on 1 side will cause the affected limb to behave as if it were short while walking.

It is also essential to consider the bigger kinematic picture, neuromuscular control, and compensation issues. When you come across 1 finding, follow the path up and down the kinetic chain, which may include tests not incorporated into the Sanford Symmetry Scale. For example: If the gluteal and hamstring muscles are weaker on the left side than on the right side, the left leg tends to internally rotate, causing the foot to strike the ground in a more pronated manner, resulting in plantar fasciitis or arch pain. With this in mind, you may find that simple inspection, such as checking for head tilt; shoulder, breast, and hip drop; patellar position; spinal curvature; and increased foot abduction yield significant clinical indicators.

LLD and a limp

A limp may be associated with acute or uncompensated LLD after trauma (sprain, strain, or fracture) or surgical intervention, such as hip replacement. A plodding limp, however, may also be associated with an LLD, which greatly increases the forces and malposition of joints in the kinetic chain. When the short limb spends less time in the contact phase of gait, pressure increases in the midfoot and forefoot during the stance phase. The result is transmission of damaging vibratory forces up the kinetic chain.

Even after the primary cause and the LLD have been addressed, some patients continue to limp out of habit. A skilled practitioner can teach the patient to walk with better balance by pointing out specific aspects of gait. Consider this model instruction:

Mr. Jones, you no longer have to limp. This is a bad habit that we can fix together. Please watch yourself walking on the screen and concentrate on getting your heels down and your toes up. Because you are rolling forward, making good use of momentum, this pattern makes walking easier and healthier.

In chronic and compensated LLD, you will usually see a limp on the long side. In a mild or early-stage case of LLD, the limp may be barely perceptible; this is when the metrics of a computer-assisted gait assessment (CAGA) system, discussed in the next section, can be invaluable.

LLD measurement techniques

The various methods of measuring LLD can be categorized as direct, indirect, and radiographic.

The direct method is conducted with the patient supine or standing. The practitioner uses a tape measure to determine, and compare, the length from the anterior superior iliac spine to either the medial malleoli or the lateral malleoli on each side.

The indirect method is conducted with the patient standing on a heel or sole lift and the practitioner leveling the pelvic landmarks.

The radiographic method is the gold standard for measuring LLD. Badii and colleagues concluded that "the indirect standing method of LLD measurement using lifts had superior validity, inter-observer reliability, and specificity in comparison with radiograph over the direct supine method of using tape measure. Both clinical methods underestimated LLD, compared with radiography."[1]

When radiographs are unavailable or the practitioner or patient elects to avoid exposure to x-rays, "methods involving palpation of pelvic landmarks with block correction have the most support for clinical assessment of limb length inequality," according to Eliks and co-workers.[2]

CAGA is a more recent, functional tool used to detect and address LLD. Using CAGA, a practitioner

Continued on page 24

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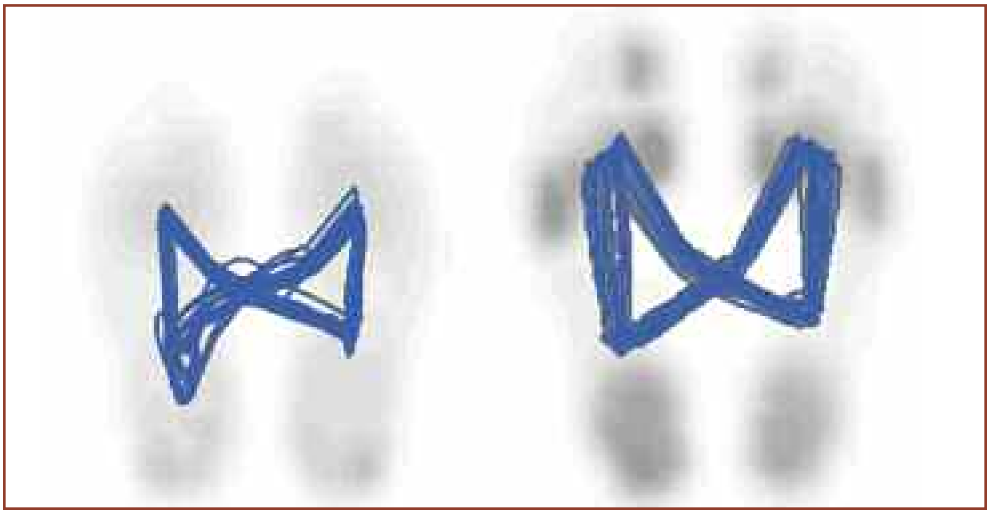

Figure 7. Center of pressure in the foot through the gait cycle. Left: Patient with a short right leg, without a heel lift. The cyclogram (blue markings) represents the center of pressure through the gait cycle; the gray area quantifies the forward shift in the body's center of gravity on the short side. Right: The same patient with a heel lift. The cyclogram shows that the center of pressure has been shifted to center and length of stance time is improved; note the change in forward shift shown in the gray area.

can approach LLD from a dynamic and training perspective—incorporating surface electromyography-assisted biofeedback, video feedback, and quantified communication strategies.

Subotnick described initial steps in the CAGA protocol:

The patient should stand on a low table with feet slightly apart, legs parallel, knees straight ahead, and arms hanging naturally to the sides. The investigator should palpate the posterior superior iliac spine. Calibrated blocks of 6 mm should be added until the pelvic spines are level. This measurement is basically for anatomical limb length discrepancies. It fails to consider the functional limb length discrepancy secondary to unilateral excessive pronation of a foot or low back imbalances.[3]

Patients with LLD are expected to exhibit a compensated (weight-bearing) long-leg pattern during gait, typically visualized as foot abduction, pronation, and dorsiflexion. You may also see a variety of findings along the closed kinetic chain, including, but not limited to, knee-joint height and the relationships among the trochanter, posterior superior iliac spine, and iliac crest (Table 2).

Table 2. LLD findings resulting from anatomic relationships along the closed kinetic chain

	High trochanter height*	Low trochanter height*
High iliac crest*	Long leg	Compensated short leg
Low iliac crest*	Compensated long leg	Short leg

*Compared to the contralateral side.

CAGA data

We advocate using CAGA whenever possible for determining the presence of LLD and its effect on the closed kinetic chain, and for re-assessment as patient education. All asymmetrical data are important, but perhaps the most important metrics and graphics generated by CAGA data analysis include the triad of heel pressure, heel off (Figure 6, page 22), and foot rotation (abduction). Further analysis of CAGA data will usually reveal:

- **Gait line length** is usually asymmetric from side to side
- **Step Length** is usually longer on the long-limb side
- **Stance time** is usually decreased on the short-limb side
- **Swing time** is usually shorter on the short-limb side
- **Step width** is usually wider when LLD is present (compared to normative data)
- **Double support** is usually shorter when LLD is present
- **Cadence** is usually lower when LLD is present (compared to normative data)
- **Heel strike** is usually asymmetric in location and timing from side to side; early heel lift on the long-limb side
- **Point of impact** is usually more medial and proximal on the long-limb side
- **Foot rotation** is usually asymmetric with increased external on the long-limb side
- **Center-of-gravity path** usually shifts medial, indicating an increase in pronation on the long-limb side when LLD is present
- **The long limb** is usually overpronated relative to the short limb at mid-stance
- **Arm swing** is usually asymmetric and increased on the short-limb side.

The great volume of data generated by CAGA notwithstanding, a successful LLD treatment plan will bring these metrics closer to normal. CAGA is particularly useful in determining whether to include a lift in a patient's treatment plan. In Figure 7, for example, the presence of balanced forefoot pressures but significant disparity in the heel region indicates the need for lift therapy. If the heel of the short side lifts off the ground within normal limits—say, 55% of the stance phase—and pressures in the forefoot are similar to those of the rear foot, we recommend a sole lift. In the case of the patient whose CAGA findings are shown here, pressures met the requirements for a heel lift. Because CAGA also revealed that he was apropulsive, a graded sole lift

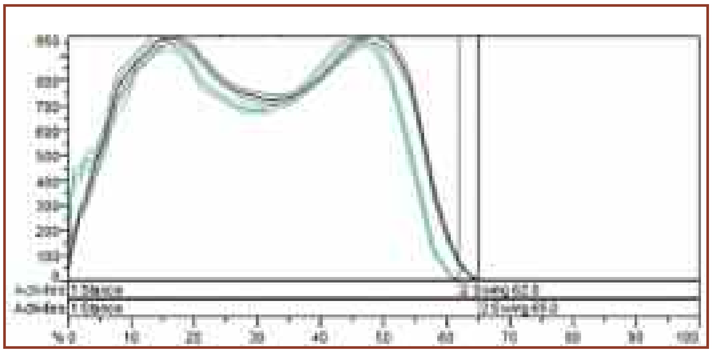

Figure 8. Ground force reaction curves in 1 patient's unlifted and corrected heel. The shaded-green/green line ground force reaction curve represents the overall force distribution through the stance phase of an unlifted heel (1 SD) at contact; this patient requires intervention with a heel lift. The shaded-gray curve is the more fluid heel-to-toe pattern of the curve after intervention; the gray line represents a healthy force distribution during the stance phase.

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Sanford Symmetry Scale©

Patient name: ____

Date: _________________________

Under the score column indicate the category of the finding S=Structural, P=Postural, D=Dynamic and allocate a score where an asymmetry = 1 and a positive finding = 1 for each side.

Tests	Category of Finding	Score
Standing Assessment		
Shoulder height	S P	
Inferior scapula angle landmark	S P	
Scoliosis test	S P	
Iliac crest heights	S P	
SI mobility tests	P	
PSIS landmarks	S P	
ASIS landmarks	S P	
Greater trochanter landmarks	S P	
Gluteal folds	S P	
Knee varus	S P	
Knee valgus	S P	
Knee flexed	S P	
Knee recurvatum	S P	
Abnormal foot/ ankle position anterior view	S P D	
Abnormal foot/ ankle position posterior view	S P D	
Great toe valgus	S P D	
Pes planus/cavus	S P D	
Standing Dynamic Tests		
Standing uniped /Trendelenberg test	D	
Heel walk weakness	D	
Toe walk weakness	D	
Seated assessment		
Seated sacral sulcus test	P	
Seated flexion test (sacral mobility)	P	
Supine Strength Tests		
Rectus femoris	D	
Sartorius	D	
Glut medius	D	
Psoas	D	
Hip adductors	D	
Anterior tibialis	D	
Peroneals	D	
Posterior tibialis	D	
Unilateral sit to stand (Quad strength)	D	

Sanford Symmetry Scale©

Supine		
Leg length /medial malleolus	S P	
Long sit test	P	
ASIS landmarks	P	
Squish test (ilium mobility)	P	
Supine muscle flexibility/Passive ROM		
Hip flexion	P D	
Hip abduction	P D	
Hip external rotation	P D	
Hip internal rotation	D	
Passive SLR	D	
Thomas Test -Iliopsoas (hip in ext rot)	S P D	
Thomas Test -Rectus femoris (knee extension)	P D	
Thomas Test- TFL (hip in abd/int rot)	P D	
Thomas test -Sartorius (knee flexed)	P D	
FABER test (Figure 4)	P D	
Side-lying Ober Test	P D	
Supine lower extremity Passive ROM		
Knee flexion	P D	
Knee extension	S P D	
Ankle dorsiflexion	P D	
Achilles length	D	
Ankle plantar flexion	D	
Great toe extension	D	
Supine manual muscle testing		
Prone landmarks		
Leg length (PSIS to medial malleoli)	S P	
Sacral inferior lateral angle	P	
Ischial tuberosity	P	
Prone manual muscle testing		
Prone hip internal rotation	D	
Prone hip external hip rotation	D	
Glut max	D	
Hamstrings	D	
	Total score	

Clinical Notes:

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would aid his forward movement patterns.

Two questions remain: How high of a lift does a patient need? And how much height can he tolerate?

CAGA systems are not only used for diagnostic purposes but can aid a practitioner in determining the amount of lift that will be appropriate and tolerated. To this end, we propose the following protocol:

- **In static mode**, have the patient stand in a symmetrical position and record the pressures
- **Reactivate the equipment** and leave it active in real time, to see fluctuations in the metrics
- **Place heel or sole lifts under the short limb** and follow the changing balance values until numbers are fairly equivalent.

Left/right and forefoot/rearfoot figures should (in a perfect world) approximate 50%-50% and quadrant pressures should be 25%-25%-25%-25%.

When a patient with LLD stands on the pressure plate of a CAGA system, the center of pressure and quadrangular pressures will often show asymmetries in the frontal and sagittal planes. The patient scanned in Figure 8 (page 25), presented with the following pattern:

- higher on the left than on the right
- posterior (rear) foot pressures greater on the left than on the right
- center of pressure left/posterior-leaning
- forefoot pressures relatively balanced from right to left.

Next steps when an LLD is identified or suspected

A practitioner now faces questions and challenges:

- Which measurement should be used to determine the extent of LLD?
- Which exercises should be incorporated?
- How much lift should be provided initially, and how frequently should the patient be re-assessed and the lift increased?
- Which finding indicates that it is time to stop increasing lift: absence of pain or correction of the LLD? Or both?

Heel-lift therapy

We propose a graduated approach to heel-lift therapy, one that takes into account slow remodeling of structural components of the closed kinetic chain (joint capsules, ligaments, tendons, and fascia), motor recruitment patterns, age, and lifestyle. A graduated approach requires frequent reassessment—at 3-month to 1-year intervals—until the patient's compensation or adaptation ceases to generate an inflammatory and painful state. (Note: A heel lift may be appropriate initially when the Achilles tendon is short or tight or there is unilateral or bilateral equinus.)

When choosing to incorporate a lift, selection of materials is an important consideration. A compressible heel lift composed of open-cellular foam (such as Poron urethane), can be effective in absorbing shock; a more rigid lift, containing high-durometer ethylene vinyl acetate, can provide greater stability and longevity.

Studying the impact transient, found as the first event on the CAGA ground reaction force curve, can assist with the decision-making process. We believe that higher initial pressures at contact are best addressed by a compressible heel lift.

We also believe that consistency is more important than balancing limb lengths when creating a treatment plan for LLD. For example: A patient who spends most of the day wearing high-heeled shoes or flip flops, or going barefoot, will have little time to wear a lift. If she refuses to or, for occupational reasons, cannot change her preferred footwear, she must commit to wearing appropriate footwear with the lift at least 1 or 2 hours a day, because inconsistent, nondaily use of a lift usually increases discomfort.

If the patient cannot wear the lift throughout the day, we recommend introducing a low degree of lift at the beginning and gradually increasing lift every 6-12 weeks, as tolerated. If the patient will not commit to wearing appropriate footwear for at least 1 or 2 hours a day, we advise against making a heel lift part of the treatment plan.

Exercises as part of an LLD treatment plan

From a rehabilitation perspective, intervention might start with strengthening and stretching, as indicated. Exercises that strengthen core and lower-limb extensors, which often become weak from prolonged sitting or asymmetrical activity, address most abnormal compensation patterns (Figure 9). Exercises such as bridges, sideline hip abduction, and prone hip extension, which stabilize the patient's core and activate the often-weak extensor muscles, result in long-term improvement. When these exercises are coupled with a lift to address LLD, the patient should be able to return to activity free of pain and relapse.

Figure 9. Outcome after improvements in foot strength and lower back tightness. Improvements resulted in 0.75-inch reduction in limb-length discrepancy. Note lateral symmetry bias: The patient usually leans to the long side—mostly likely the result of pelvic overcompensation.

Amount of lift, reassessment, and graduation protocol

Bear in mind that, because the body goes through compensatory changes when a person has been living with LLD over the long term, adding a heel lift alters those musculoskeletal accommodations slowly and provokes an inflammatory state, which, in turn, will induce tissue remodeling. The goal of treatment is to induce mild, acute inflammation; if the correct degree of lift is introduced gradually, adding a heel lift will not be painful. If the patient experiences pain, the lift height needs to be reduced.

Some patients develop effective compensation patterns, particularly when the LLD is <5 mm. Adding a lift to such a patient's treatment plan often results in more harm than good. According to Subotnick, "work among the advocates of applied kinesiology has shown that an unnecessary heel lift results in a unilateral weakness. An uncorrected limb length discrepancy likewise results in unilateral weakness."[3]

Assuming patient adherence, acute causative factors, and mini-

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CASE: Antalgic gait and LLD in an elderly man

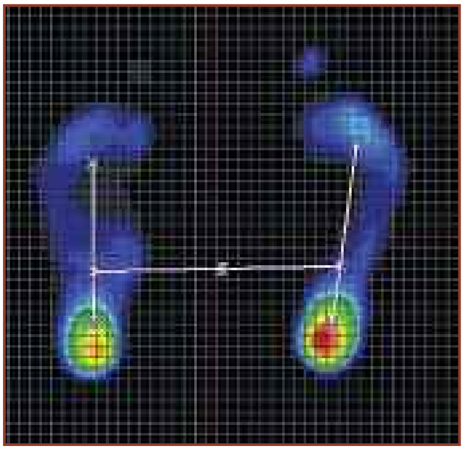

Figure. Imbalance before heel-lift intervention. Static CAGA scan reveals imbalance that corrected itself when a graded, sulcus-length sole lift was introduced under the left foot (starting with a 0.25-inch lift and increasing to a 0.50-inch lift, which was comfortable and achieved the balance sought).

History. A 64-year-old man was referred to a podiatrist for evaluation and management of antalgic gait and LLD. His chief complaint was pain in the feet and hips. He reported substantial recent weight gain because of pain and a consequent decrease in activity.

The patient had been seen for an ingrown toenail on the left foot 3 years earlier, at which point he had asymmetric pronation and greater overpronation on the left—likely a contributing factor in the development and progression of his nail problem on the left foot. At that time, in addition to nail care, CAGA was performed and a recommendation to wear wider shoes and an orthotic was made. The patient reported that he had changed his shoes based on the practitioner's recommendation.

Physical examination. The exam revealed an obese man with a short right leg of ¾ inch that was measured, while he was seated in the examining-room chair with legs extended, from the anterior superior iliac spine to the medial malleolus. The short right leg was also observed by measuring the medial malleoli while he performed a sit-up exercise. Palpation of the lateral plantar surface of the midfoot on the right side was painful. A spinous callus was located on the first metatarsophalangeal joint of the left foot. An ingrown medial nail margin was observed.

The patient displayed an imbalance in muscle strength and flexibility in the leg pronators and supinators and the quadriceps and hamstrings. While bearing weight, he had an asymmetric, antalgic posture, leaning to the left with compensation, extending through the closed kinetic chain.

Neurological and circulatory systems were relatively unremarkable.

Imaging. Radiographs taken previously showed significant degeneration and arthritis within the right hip joint. Dynamic CAGA revealed:

- **Abnormal and unsteady gait** with a limp and excessive pressure in the left lateral column and forefoot, and the right medial foot.
- **Asymmetric pronation, heel off;** impact transient findings (left limb: increased pronation and medial heel impulse, impact transient present but small; right limb: extended but earlier heel off compared to the left [apropulsive gait], higher impact transient and lateral heel impulse, compared to the left).

When comparing earlier CAGA to current CAGA, the minimal asymmetry documented 3 years ago had become significant, a progression validated by worsening symptoms. The podiatrist postulated that muscular imbalances (Figure) and skeletal malalignment resulted in biomechanical compensation and contributed to a long-standing, functional, progressive structural (right-hip arthritis) and functional LLD (abnormal compensation to create a functional short left limb).

Treatment. It was determined that the patient fit the criteria for LLD treatment with a heel or sole lift. After discussing options, the patient decided to proceed with a heel lift in conjunction with custom orthotics and supportive footwear.

Discussion. Notwithstanding the findings of the physical exam and CAGA testing, and other available diagnostic information, the ultimate goal of a treatment plan will not necessarily be achieved at the initial visit. For chronic cases, we recommend that treatment begin at half of the final goal and the body adjust to its new reality with subjective and objective monitoring. Then, height is gradually increased over subsequent weeks or months.

Some patients' proprioception will be affected, changing their pressure distribution so that it appears erratically different from the original findings. If this occurs, you may find that removing the lift does not return the patient to baseline findings. Recognize, and communicate to the patient, that adding the lift is changing neurological input from the feet to the brain. Teach the patient that muscles and joints will move in a different pattern, which is why you start with a low lift. It is also important that the patient be instructed to report pain or discomfort to you.

Because a heel or sole lift addresses only 1 plane of movement, a custom orthotic may also be recommended to enable adaptation through the closed kinetic chain (foot, ankle, knee, hip, pelvis, and spine) in all 3 planes (transverse, frontal, and sagittal). You may also need to address gait learned behavior, muscle memory, and recruitment patterns that were adopted by the body to cope with asymmetric function. In other words, now that you have adjusted musculoskeletal alignment, the body will learn different gait strategies through neuromuscular exposure to the sole lift and custom orthotic.

This is another opportunity to use CAGA for therapeutic purposes in an LLD patient. By using a treadmill-based CAGA with cameras and a large-screen monitor, you can provide gait training and visual cueing while gathering metrics for comparison as the patient progresses through the treatment plan. Our experience suggests that 12 to 16 visits of the office-based repetitive movement exercises help to retrain the muscles and undo poor gait habits.

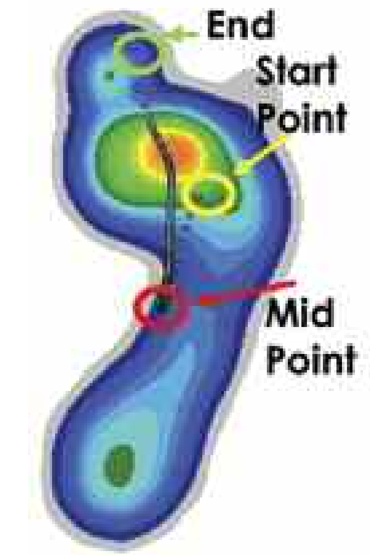

Figure. Dynamic CAGA reveals apropulsive gait (120 samples/second)

Continued on page 34


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Continued from page 30

mal musculoskeletal accommodation, we recommend raising the short limb by 50% of the LLD with a graded, sulcus-length sole lift. For example: For an LLD of 8 mm, begin by selecting a 4-mm lift, re-examining the patient every 3 months, and adding height until the biomechanics of the closed kinetic chain are balanced (best assessed by CAGA) and the patient can perform ADL or work without pain.

Indicators of treatment success

Whether the treatment plan calls for movement and exercise progression or adjustment and device intervention, we recommend beginning slowly so that the musculoskeletal system, including ligaments, joint capsules, and tendons, can remodel gradually without inducing a robust inflammatory response. During either therapeutic approach, the key is to identify each area of dysfunction along the closed kinetic chain and determine whether the body has compensated for the imbalance. As noted, success is achieved when the patient's biomechanics have improved and he can perform ADL or work without pain. Most adult patients who have chronic LLD will need to use a lift for the rest of their life. Children and adolescents require periodic reassessment until growth plates fuse.

Conclusion

Our aim in this article has been to provide a thorough, evidence-based understanding of 1) how to assess for LLD and 2) the impact of LLD on muscles, bones, joints and movements, as a means to undertake a comprehensive treatment plan. In most cases, LLD patients require a comprehensive, cross-disciplinary treatment plan that might include a podiatrist, physiotherapist, chiropractor, kinesiologist, and athletic therapist. Objective diagnostic and treatment modalities, such as the novel Sanford Symmetry Scale and CAGA, allow for effective communication with the patient and within a cross-disciplinary team; provide metrics to design an LLD treatment protocol; and can be used monitor a patient's progress.

Jay Segel, DPM, is in private podiatry practice, Martha's Vineyard, Massachusetts, and is Director of Applied Podiatric Biomechanics at Noraxon USA, as well as a podiatric advisor and member of the medical education staff at Orthotic Holdings Inc. Susan Sanford PT, L.Ac, C.SMA, is President and Chief Executive Officer, Vineyard Complementary Medicine, West Tisbury, Massachusetts. Sally Crawford, MS, is Chief Operating Officer and Director of Biomechanics, Resilience Code, LLC, Englewood, Colorado. Lori Yarrow, DC, BPE, is a marketing and education consultant in the orthotics and medical devices industry.

Sources: Figures 1,2, 4-11: CAGA screenshots by author (using myoMOTION and myoPRESSURE technology with MR3 software [Noraxon USA, Scottsdale, AZ]). Figure 3: Lower Extremity Review (2016). Sanford Symmetry Scale is Copyright © Susan Sanford, PT, L.AC, C.SMA.

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Implications of asymmetry in the treatment of injured athletes

Given that many uninjured, successful athletes have some degree of asymmetry, how do clinicians interpret asymmetry in athletes recovering from injury?

By Cary Groner

Champion track sprinter Usain Bolt has what was known colloquially as a "hitch in his get-along." Bolt, who retired from competition in 2017 after an extraordinary athletic career that includes gold medals in the 100- and 200-meter events in three consecutive Olympic Games, has scoliosis, and consequently his right leg is approximately one half-inch shorter than his left leg.[1] The result is an asymmetrical stride. Researchers found that Bolt struck the ground with 1,080 pounds of peak force on his right leg and 955 on his left.[2] Asymmetry occurs in healthy athletes as well as those who are rehabilitating from injury. Assessing the importance of asymmetry in injured athletes is, therefore, not straightforward.

A host of variables

Research has demonstrated statistically significant differences between left and right sides in both kinetic and kinematic measures in healthy subjects and have reported that people typically use different legs for stabilization, braking, or propulsion while walking, even controlling for dominance.[3-5] This functional asymmetry appears to be common.

Turning to asymmetry in athletes, Scandinavian researchers reported that 11 of 22 competitive sprinters displayed large or very large asymmetry in at least 11 of 14 variables measured and that all of the athletes had asymmetry in at least three variables—but found no significant correlation between the magnitude of individual asymmetry and sprint performance.[6] Other research suggests that asymmetry does not affect sprint performance because the ankle joint may regulate its effect.[7]

Fatigue-induced changes in gait may increase asymmetry in knee movement patterns. Using both kinetic and kinematic measures to assess asymmetry, researchers found that variables previously associated with overuse injuries (eg, knee internal rotation, knee stiffness, loading rate) were significantly different between limbs in both rested and fatigued states.[8]

"We did find asymmetry in a healthy population," said Kara Radzak, PhD, ATC, the paper's lead author. Radzak, assistant professor in the Department of Kinesiology and Nutrition Science at the University of Nevada Las Vegas, said, "I think our most interesting finding was that some gait factors become more symmetrical

Can various measures of symmetry be used to predict reinjury to the lower extremity in sports?

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with fatigue and others become less symmetrical," she said. "The variables that got more asymmetrical were those associated with knee overuse injuries, those based on eccentric control of the musculature. Conversely, variables such as loading rate became more symmetrical."

Radzak believes such changes indicated how those in the study population modulated fatigue. "As we move from a rested to a fatigued state, we may use up our ability to eccentrically control ground forces and go to more of a bony-absorption mechanism," she explained. "What that tells us is that we need to be looking at patients in multiple states, because their motion may be different when they're rested and when they're tired."

Sport-specific symmetry

Other research has produced heterogeneous results about the prevalence of gait asymmetry, as well as implications for athletes in various sports. A 2006 study reported that previously injured runners may remain closer to injury threshold than those without an injury history and that asymmetry may influence only the side on which a subsequent injury occurs. [9] A 2008 paper found that although some degree of asymmetry is normal in runners, those with a history of injury, certain variables (hip internal rotation range of motion [ROM] and peak tibial acceleration) were elevated on the injured side, and that such variables were often bilaterally elevated in injured runners as well. [10]

A study of uninjured professional rugby players reported that 55 of 60 variables studied indicated symmetry (the players performed a drop landing, a hurdle hop, and a cut), whereas the other five variables were asymmetrical. [11] Greek researchers concluded that of seven variables studied in young male runners—leg stiffness, vertical stiffness, contact time, flight time, maximal ground reaction force (GRF) during contact, vertical displacement of the center of mass, and change in leg length—significant asymmetry was found only in flight time and maximal GRF. [12]

Other research on sport-specific symmetry has found that—

- vertical-jump asymmetry is typically 10% - 15% in both male and female volleyball players; [13]
- asymmetrical step lengths, possibly resulting from underlying imbalances, existed in 12 of 35 race walkers in the United Kingdom; [14]
- professional soccer players tend to display lower isokinetic strength asymmetries the longer they've been in the sport; [15]
- in 21 healthy young athletes, 26% exceeded 10% asymmetry in quadriceps and hamstring muscle volume (with 10% considered a normal variation); [16] and that
- over short distances, gait asymmetry in runners with a history of injury was higher than in those without an injury (the authors did not determine whether the asymmetries preexisted or resulted from the injury). [17]

In the clinic

What does all this mean to clinicians? Symmetry measures are often used to gauge recovery after injury, particularly those to the anterior cruciate ligament or Achilles tendon. But if some degree of asymmetry is normal in healthy individuals, how do clinicians interpret asymmetry in athletes recovering from injury?

"It's a great question," acknowledged Robin Queen, PhD, associate professor of biomedical engineering and mechanics at Virginia Tech and director of the university's Kevin P. Granata Biomechanics Laboratory. "Paterno showed that side-to-side asymmetry was a risk factor for a secondary tear, [18] but it's really hard for us to explain to a clinician what that means. How do we know that a person in rehab with 12% asymmetry didn't start out that way before their ACL tear? The goal in rehab is usually to get patients to 90% symmetric, at which point most clinicians would release them for return to sport [RTS]. But why do we have so many secondary tears? I think we have to consider that maybe it's not about distance but about how patients are accomplishing a given task, and that's why we're working to find a metric around movement quality."

Asymmetry can be measured in various ways—eg, strength, ROM, muscle volume, kinetics, kinematics—and Queen thinks opinions are still evolving about the most effective approach.

"Most clinicians have been clearing patients for RTS based on quadricep/hamstring ratio and side-to-side strength deficits," she explained. "Strength assessment in the clinic is important, but when we ask patients to do something more functional, we need to know if the neuromuscular system is really reacting the way we expect it to. If there is kinesiophobia—fear of movement—we may need to re-

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train them so that they understand that the limb is strong enough to take that load."

Queen noted that some variability is not only natural but might also be desirable. "If you only know how to accomplish a task in one way, what implications does that have for a secondary injury?" she asked.

In her own research, Queen has shown that a year after anterior cruciate ligament reconstruction (ACLR), subjects still had significant between-limb asymmetry in several measures.[19] "It's pretty clear that six months isn't enough recovery time—certainly in terms of movement, but also in terms of graft vascularization," she said. "Even at 18 months, at two years, they're not moving at what we want to term 'normal.' I think we need to combine the worlds of injury prevention and postinjury therapy to get them playing again without confusion about the risk of a secondary tear."

ACLR issues

Additional research demonstrated that hamstring strength asymmetry persists three years after ACLR with a hamstring tendon autograft, and affects involved knee mechanics during gait and jogging.[20] "Even very high-level athletes, like those in the NFL, may take two years to get back—and these are guys who have a trainer, a physical therapist, a strength coach, a physician, a whole team working with them every day, guys who are motivated because it's their living," said Timothy Hewett, PhD, director of biomechanics laboratories at the Mayo Clinic in Rochester, MN, and the clinic's John and Posy Krehbiel endowed professor of orthopedics.

Hewett acknowledged that existing measures of symmetry, often called limb-symmetry indices or LSIs, often aren't adequate for the task, and research supports this position.[21-22]

"These measures are problematic, partly because people may naturally have a 10% variation between limbs, and the error in our measurements is 10% – 15%," he said. "So that difference may not be meaningful, or it may be within the scope of error. Symmetry is important, though—we know that asymmetries in movement and kinematics are some of our best predictors for subsequent injury—so we need other measures as well."

According to Hewett, the loss of an ACL also entails the loss of proprioception provided by the mechanoreceptors in the tendon, and this has repercussions throughout the kinetic chain—including surprising effects on symmetry.

"Those receptors have multiple functions including spinal-level feedback loops that send information about position, force, and torque on the ligament," he said. "But an ACL reconstruction doesn't restore those receptors, so neurosensory deficits arise. Your body can't increase performance on the injured side, but it still seeks symmetry, so it decreases performance on the uninvolved side."

Hewett noted, moreover, that the body's tendency to seek symmetry postinjury may lead to complex adaptations through the chain.

"What's primarily important is the transfer of force through the ankle, knee, and hip," he explained. "If you look at total force generation across those joints, it is usually highly symmetric, even though the individual joints may not be. That means that if you have a deficit in your knee on one side, the body increases the force generation at the ankle."

This may be a good thing, of course, but it may also lead to improper joint mechanics, inflammation, and osteoarthritis, as well as an increased risk of reinjury.[23]

"When your hip and knee go through greater ROM during a task, it's going to dissipate the ground reaction forces, but after ACLR, when you don't sense that joint as well, the ROM decreases in the hip and knee, and the GRF tends to be higher," Hewett said. "You also tend to favor the uninjured side because you feel it more, so then the forces on that side go up, creating even more asymmetry, which we think increases the risk of a subsequent contralateral tear."

In 2010, altered neuromuscular control of the hip and knee following ACLR were reported as predictors of a second ACL injury,[24] and earlier research found that neuromuscular control and valgus knee loading predicted ACL injury in female athletes[25] and that limb asymmetries persisted at two years post-ACLR.[26] A 2016 meta-analysis in *Sports Medicine*, moreover, found that knee function is not fully restored five years post-ACLR,[27] and several papers have reported similar effects on symmetry in the quadriceps, including measures of strength, volume, and neural function.[28-30]

Christopher Kuenze, PhD, an assistant professor of kinesiology at Michigan State University and lead author of several of those papers, told LER that he and his colleagues were interested in a variety of factors related to asymmetry. One question was why post-ACLR patients tended to offload the involved limb, consciously or unconsciously, even after completing rehab.

"Our hypothesis is that it's likely due to pain, discomfort, and trust in the limb, and I think it becomes a learned behavior over time," he said. "It would be great if you had a physical therapist in your closet you could take out when you need to, because I think this kind of problem needs to be treated more like a chronic disease than an acute injury."

Kuenze believes that clinicians and researchers should choose assessment variables

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based on the long-term outcomes they want to measure.

"If your concern is reinjury risk, then you probably want to measure functional symmetry early in the process leading up to return to sport," he said. "If you're more interested in long-term joint health, you may want to assess symmetry during activities of daily living, things like walking gait."

He echoed Tim Hewett's concern about the body seeking symmetry by weakening the uninvolved side, as well.

"If your injured limb isn't functioning well and you're symmetrical, it means your uninvolved limb is probably not functioning well either," he said. "So whether it's reinjury risk or long-term joint health, it's not an optimal situation."

The Achilles heel

The Achilles tendon also can affect symmetry, even when uninjured. In healthy athletes without a history of Achilles injury, the amount of asymmetry between legs rose as high as 31% in terms of mechanical and morphologic properties.[31] A 2017 study from Brazil, moreover, found that injured patients who underwent surgical Achilles repair retained long-term asymmetries in ankle stiffness and plantar flexor function.[32]

"When you have an injury to the Achilles, the tendon lengthens and you have permanent changes to the ankle that affect function,"[33] said Karin Grave Silbernagel, PT, PhD, an assistant professor of physical therapy at the University of Delaware in Newark.

"Your body compensates by using the knee, the ankle, and the hip, which is probably a good accommodation," she continued.[34] "The problem is that clinicians often think that if the patient doesn't achieve symmetry in the ankle, they shouldn't return to sport. But the nature of an Achilles injury is such that they will never be able to do as high a heel lift as on the uninjured side, so that can't be the basis of your RTS decision. Instead, you can measure the total amount of reps at a certain height, or how far they hiked. When the patient is ready, he or she should return to running or jumping; they just need to know that the knee will be working harder."

A relationship between symmetry and fatigue also has a role in the RTS decision. "We guide return to sport based on how long you can keep your running pattern without losing symmetry," Silbernagel said. "We know that the amount of load matters in the recovery process. If they do too much they get worse, but if they do the right amount they can build and get better. If you don't have good form, you may be overloading the tendon—and that's where we should stop you."

Symmetry in return to sport

In determining when an injured athlete is ready to return to sport, Silbernagel considers several factors. "Overall, we want to use a test battery that includes range of motion, strength, endurance, jumping performance, all those things," she said. "You need to focus on the task at hand, and if you can't achieve it, is there a way for the body to compensate? Because if there isn't, then the patient is put at a much greater risk of reinjury or failure."

Chris Kuenze and his colleagues consider RTS a staged approach. "Our first goal is to restore involved limb muscle function," he explained. "Second is to restore the limb's functional performance on tasks like hops and stair climbing. Third is to restore between-limb

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symmetry. The hope is that by restoring involved limb function you will have already achieved goal three, but it doesn't always work out that way. What you don't want is to achieve symmetry without restoring function in the injured limb, for all the reasons we've discussed."

"We need to look at people more holistically," said Robin Queen. "We can't just focus on the part that was injured; we have to consider what's above and below it in the kinetic chain, as well as the contralateral limb. That's the way to get the athletes back to feeling confident, to knowing their body will respond when they're back on the field."

"We have to come up with multiple ways to create parallel circuits to allow our bodies to sense movement and forces, and to adjust," he said. "We want to test people before they return to sport using four or five factors that we know lead to increased risk,[35] then use rehabilitative tools to enhance those to decrease risk. The idea is to deal with strength, symmetry, and kinematics, but also to look at proprioception and kinesthesia. We have to consider all options because the risk of re-injury is just too high." ler

Cary Groner is a freelance writer.

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Patient comfort vs diabetic wound healing: confronting nonadherence associated with removeable offloading devices

Patient adherence to consistent use of removeable offloading and immobilization devices is central to promote healing and prevent infection in diabetic foot ulcers, yet the tradeoff of removability easily compromises adherence. Choosing and customizing the right device is key.

By Barbara Boughton

A mainstay of treatment for diabetic wound care is the use of offloading and immobilization devices that allow patient mobility while reducing pressures on the foot that hamper wound healing. Total contact casts (TCCs) are the gold standard for healing diabetic wounds—particularly for large wounds that are difficult to heal—but TCCs are heavy and cumbersome and cannot be removed for sleep or showering.

Tall (to the knee) removable cast walker boots are more acceptable to patients, but because these devices are removed easily, patients do not always fully comply with their use, compromising wound healing. Research has demonstrated that diabetic patients wear their prescribed removeable cast walker for less than 30% to 60% of daily steps. [1,2]

An advantage of a removable device is that wound inspection is accomplished more easily than with a TCC, and a patient who notes swelling or signs of infection after taking off a removable device can seek treatment. However, patients often do not appreciate the importance of such devices in ulcer healing, a view that may affect adherence.

> Many practices have moved toward wrapping removable cast walkers in cast tape or other material after they are applied—essentially making them irremovable.

Offloading removeable devices

The challenge for clinicians is to design devices that will improve patient adherence with the use of removeable devices without compromising efficacy. Although taller devices are generally more effective than ankle-height devices, taller devices tend to be heavier and may affect the wearer's gait and balance.

Researchers in a 2012 study were among the first to assess the effect of strut height on the offloading capacity of a knee-high device, an ankle-high device, and an orthotic shoe offloader in 11 di-

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abetic patients at moderate to high risk for ulceration. An athletic shoe was used as a control. Each study subject completed four 20-meter walking trials in each of the three devices and the control shoe. Both the knee-high and ankle-high devices performed significantly better than the shoes in offloading. Peak pressures were slightly greater in the ankle-high device than the knee-high device. Peak pressure at the hallux, for example, was 76kPa in the knee-high device compared with 90kPa in the ankle-high walker. [3]

Yet the body's center of mass range of motion during the patient's first four steps in the ankle-high walker was lower than with the knee-high walker—signaling a potential lower risk for a fall. Those first four steps are a high-risk time for falls, according to Ryan Crews, MS, CCRP, lead author of the study and clinical research scientist and operations manager at the Center for Lower Extremity Ambulatory Research in Chicago. Because the ankle-high device was less cumbersome and caused fewer balance problems than the knee-high device, it may have the potential to improve adherence in patients wearing a removable cast walker, and thus improve wound healing, the researchers concluded. "Considering the ankle-high removable cast walker was a nearly equivalent offloader to the knee-high removable cast walker, while weighing less and potentially providing better stability, it may prove to provide better outcomes in treating diabetic foot ulcers," they wrote. [3]

"The slight reduction in offloading may be offset by improved adherence," said Crews. The knee-high removable cast walker also resulted in a slower walking speed than was seen with the shorter walker. "Slower speed in walking has been linked to falls in previous research. These patients are physically deconditioned, so adding a big, heavy boot will just increase their challenges in walking," Crews said.

Hallux interphalangeal joint wound treated with a total contact cast over 3 weeks. Courtesy of David Armstrong, DPM, MD, PhD, Southern Arizona Limb Salvage Alliance.

In a 2016 study of 79 patients with diabetic foot ulcers, Crews and fellow researchers found that postural instability with removable cast walkers contributed to reduced off-loading adherence. [2] Factors that predicted improved adherence included larger and more severe baseline diabetic foot ulcers, more severe neuropathy, and greater foot pain. The researchers also found that better offloading adherence was linked to greater healing of ulcers over a six-week period.

An abstract presented by Crews at the 2017 American Diabetes Association annual scientific meeting also documented that removable cast walkers induced changes in spinal alignment, sagittal balance, pelvic tilt, and lordotic angles while walking compared with walking while wearing an athletic shoe. [4] Both knee-high and short walkers would be expected to have similar effects on spinal alignment, although the 2017 study evaluated only knee-high walkers, Crews said. A contralateral lift reduced the limb length discrepancy and subsequent balance and gait problems. "The removable cast walker induced changes in spinal alignment that could contribute to back pain and, subsequently, poor removable cast walker adherence. However, a contralateral lift may improve removable cast walker adherence by mitigating spinal alignment changes," Crews said.

The next step for Crews is to study adherence and ulcer healing rates in diabetic patients wearing an ankle-high removable cast walker. Yet there's no question that while TCCs and removable cast walkers have demonstrated similar capacities for offloading diabetic foot ulcers, research has demonstrated that patients who wear TCCs have better outcomes. The reason? TCCs must be cut off to be removed, whereas patients will often take off a removeable cast walker to sleep or when they're at home. "As a result, they're at increased risk for infection as well as nonhealing of the ulcer," said

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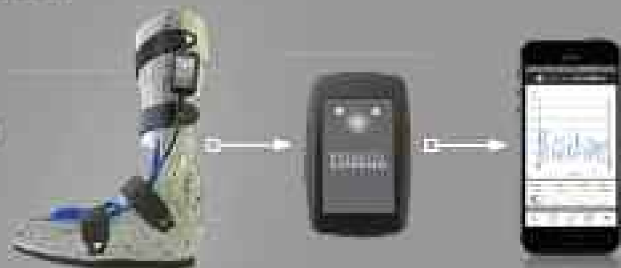

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Adam Isaac, DPM, a podiatric surgeon at Kaiser Permanente Mid-Atlantic States, Largo, MD. When patients don't wear their offloading devices, they can also develop new wounds because of neuropathy, Dr. Isaac noted.

Both TCCs and removable cast walker boots have the potential to cause injury, owing to the postural imbalances they create, which can cause hip as well as back pain. "Although it's rare, TCCs and controlled ankle motion boots can also cause additional pressure ulcers—some serious enough to require surgery," said Dr. John Steinberg, DPM, professor in the department of plastic surgery at Georgetown University and president-elect of the American College of Foot and Ankle Surgeons.

In the clinic

Dr. Steinberg prefers TCCs for his patients with diabetic foot ulcers. TCCs improve adherence, said Dr Steinberg, adding, "although some patients absolutely refuse to have a TCC. If we run into strong patient resistance, we will try a removable cast. But if the wound doesn't heal, we'll then suggest a TCC again, and at that point, the patient usually agrees," he added. Dr. Steinberg also noted that the type of deformity in the diabetic foot also has a role in the type of device chosen. For example, significant bony deformity calls for a TCC more than does a tissue deformity.

Dr. Isaac usually recommends a TCC for his diabetic patients with hard-to-heal ulcers, particularly if the ulcer is large or if the patient has a significant deformity, such as Charcot foot. At the very least, patients with large ulcers and foot deformities should wear a tall removable cast walker boot, he noted.

Although many clinicians favor TCCs, they are used less often than removable cast walkers because of the expertise needed to apply the TCC and patient resistance.[4,5] Many practices have moved toward wrapping removable cast walkers in cast tape or other material after they are applied—essentially making them irremovable. The application of a removable cast walker in this manner does not require the specialized expertise demanded of a TCC, and the device is not easily removed by the patient—theoretically improving adherence and healing, said Dr. David Armstrong, founder and director of the Southwestern Limb Salvage Alliance, and professor of clinical surgery at the Keck School of Medicine at the University of Southern California.

The orthotist and pedorthist also have greater flexibility in customizing a removable device, such as by adding straps for adherence and adjusting for gait, said Eric Burns, CO, regional director of Hanger Clinics in Arizona.

Short walkers vs tall

Shorter removable cast walkers are more popular with patients than are taller devices. "Many of my patients with diabetic ulcers do prefer a short device set about the ankle level. These devices are easier to take on and off and less cumbersome than higher devices that come to the knee," Dr. Isaac said. Short devices can be particularly useful in offloading small diabetic ulcers in patients without major foot deformities, he noted. "I usually prefer to sacrifice a little offloading capacity with a shorter device— if it will improve patient [adherence]," he added.

In his practice, Burns has found that although a shorter removable device will have less of an effect on balance and gait than a taller removable device, not all patients can use a shorter device. "A taller device would be a better choice for patients who need to heal from more serious wounds or have more serious deformities," he said.

Emphasis on patient education for adherence

An ideal offloading device for a diabetic foot ulcer is one that maintains correct foot mechanics, enables the patient to have variable range of motion, and offloads pressure points, according to Robert Tillges, CPO, owner of Tillges Certified Orthotics and Prosthetics in Minneapolis, MN. Removable devices are generally more comfortable and promote better hygiene and wound care. "Still, you must have [an adherent] patient for these devices to be effective," said Tillges.

Due to the high rate of patient nonadherence with removable offloading devices, patient education is vital, Dr. Steinberg agreed. Steinberg makes sure to explain to his diabetic patients with pressure ulcers the risks and benefits of wearing a removable offloading device. "If a patient truly understands the risks and benefits, he is more likely to be [adherent]," he said. To enhance adherence, Dr. Steinberg will even share with patients scientific papers detailing the efficacy of offloading devices for healing diabetic ulcers.

"Simply reminding people is not enough," Crews said. "Patients get a false sense of safety in their own home, which leads to nonadherence in the home."

A thorough foot assessment and complete medical history are crucial before deciding on the type of device and before designing a device for each patient, according to Tillges. Evaluating the patient for acute, chronic, or recurring problems is important. An older adult with osteoarthritis who is already at risk for falls, for example, may benefit from a lighter device that provides better balance. "The device also has to be designed to reduce enough shear and pressure, while also ensuring good biomechanical alignment," Tillges said.

"Whichever device is used, we want to make sure we're doing everything we can to get diabetic patients with wounds up and moving safely so they can heal. Safe mobility can have a dramatic effect on wound outcomes," Burns added.

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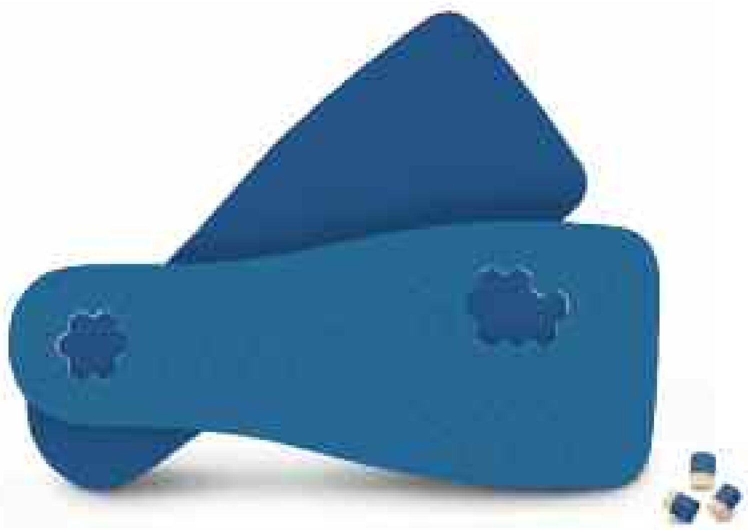

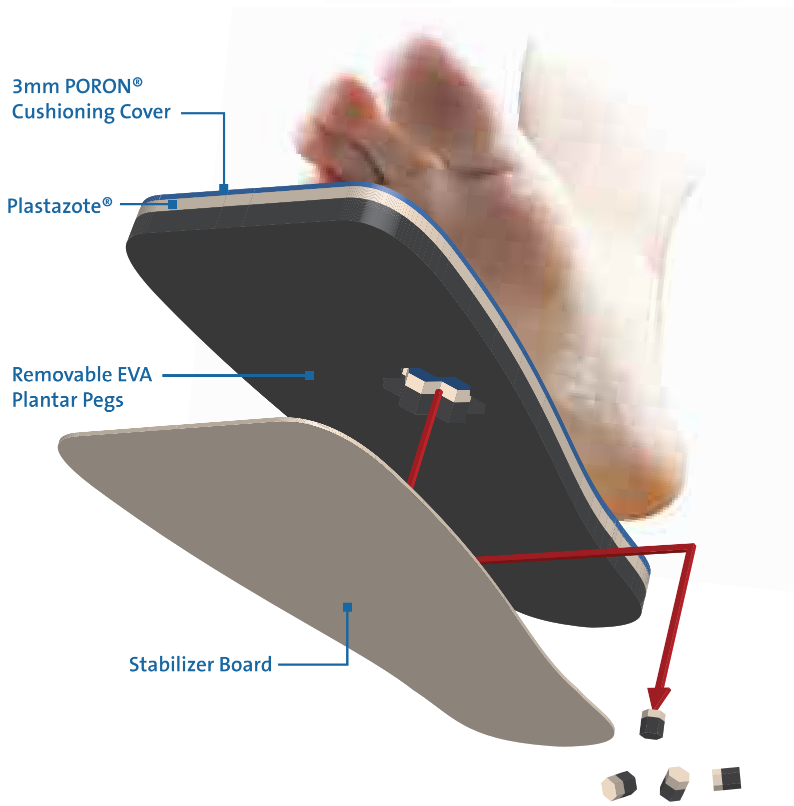

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Do specialty shoes boost weightlifting performance?

Sport-specific shoes may protect athletes from injury or enhance their performance. Do specialty weightlifting shoes offer these same benefits? What effect do the shoes have on posture, rearfoot force production, ankle range of motion, the ability to bend the knee deeply, and other parameters? Research is mixed.

By Jill R. Dorson

Weightlifting shoes generally employ an inflexible, noncompressible sole; rigid bottom; and a heel elevated typically by 2.5 cm.[1,2] The design is to provide the weightlifter with a good base from which to lift, some protection for the lumbar spine, and improved lifting posture.

Saleena Niehaus, DPM, AACFAS, a foot and ankle surgeon in State College, PA, notes that the sole of a weightlifting shoes may be made of wood or thermoplastic polyurethane to improve stability by creating a rigid heel cup. The rigidity and stability of the shoe will allow for smoother landings in the snatch and clean-and-jerk movements compared with other athletic shoe gear, and that the elevated heel provides greater dorsiflexion at the ankle joint. "The slight elevation of the rearfoot relative to the forefoot may have a positive effect in increasing the activity of the quadriceps femoris muscles," said Niehaus. "Increased activity of the quadriceps muscles enables the athlete to be more powerful as he or she returns from the bottom of a squat or reaches full extension through the lower extremity in the snatch or power-clean lifts."

One consistency among studies of the usefulness of weightlifting shoes is that standardization across the research is needed, particularly the depth of squat.

Sifting through the evidence

What evidence demonstrates that weightlifting shoes have an effect on weightlifting performance?

Researchers in a 2017 study in the *Journal of Strength and Conditioning Research* asked 14 recreational weightlifters to squat with 80% of their single-repetition maximum while barefoot on a flat surface, barefoot on a heel-raised platform, and wearing weightlifting shoes.[3] The authors concluded that raising the heel either with a platform or a shoe did not significantly alter the biomechanics and was therefore unlikely to improve biomechanics or protect the athlete's back during squats.

Twenty-four male and female experienced weightlifters were asked in a 2016 study to perform back squats at 80% of their single-repetition maximum while wearing no shoes, wearing weightlift-

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ing shoes, and wearing running shoes. [1] The goal was to investigate how specialty shoes affect biomechanical loading during the exercise. The researchers concluded that weightlifting shoes only marginally changed biomechanical loading, and therefore they offered limited advantage to athletes.

Other research demonstrates that weightlifting shoes may help athletes with limited squat depth to achieve greater squat depth without compromising posture. [4] Male and female athletes of varying weightlifting experience performed squat exercise while wearing athletic shoes and again while wearing weightlifting shoes.

"In the novice lifters, we demonstrated a reduction in ankle angle and an increase in knee angle…both with and without load. This would suggest that there are some benefits for novice lifters, too," said lead author Hayley Legg, MRes, FHEA, CSCS, ASCC, a senior lecturer in strength and conditioning science at St. Mary's University in Twickenham, UK. "Even with small benefits, marginal gains can be achieved in a performance and recreational setting," added Legg.

A 2012 study concluded that use of weightlifting shoes increased foot segment angle and decreased forward trunk lean.[2] The study, which involved experienced college-aged weightlifters, concluded that wearing weightlifting shoes helped athletes achieve the recommended vertical position used for squatting.

Apples and oranges?

Although practitioners generally agree that using a weightlifting shoe at elite or novice levels is not harmful, comparing study results can be a challenge, with variability in the depth of the squat that study subjects were asked to perform, equipment used, and the subjects' weightlifting experience.

Carl Valle, a track coach and sports science performance consultant based in Boston, observes that standardizing the depth of the squat among studies would be helpful in interpreting the data. "If you were to standardize the depth, then maybe there is something. The question is: What's the advantage of going deeper? Maybe there is a benefit of that range or maybe they need [a deeper range] to compete properly. That's my unknown territory.… What happens when you go really deep in a squat?"

Available research provides no clear answer to that question. For example, a 2015 study sought to determine whether weightlifting shoes were beneficial to rearfoot force production. [5] Twenty male athletes with a range of weightlifting experience were observed performing barbell back squats under 4 different conditions: wearing low-end weightlifting shoes, high-end weightlifting shoes, athletic shoes, and athletic shoes while elevating the heel on a weight disc. Athletes lifted 75% of their single-repetition maximum. The results were not what the investigators anticipated: Not only was there no effect on rearfoot force production, but there was also little-to-no change in the ankle range of motion or the ability to bend the knee to get a deeper squat.

Like many other researchers, Thomas Schermoly, lead author of the study, found the process frustrating and the results at odds with his expectations.

"We did find a few differences before and after the squat, but because that didn't indicate differences in the motion," those results weren't relevant, Schermoly said. "I did mention toward the end of

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the study [publication] that there were limitations.… We weren't able to control how each athlete descended and ascended. They were at different speeds, had different styles. Because we were looking at rearfoot stress production, we didn't want to tell the subjects that they should push through the heels. We didn't want it to alter the integrity of the study." Schermoly noted that some study subjects were unable to achieve the requested 90-degree angle.

In addition to standardizing the depth of the squat, current research is focused on how weightlifting shoes can affect the biomechanics of only one movement—the squat—while the key moves in elite weightlifting are the snatch and the clean-and-jerk. Though squatting certainly plays a role in both moves, neither has been studied specifically.

"The squat is an integral part of both the snatch and the clean," Legg said. "In order to lift more weight, [athletes] need to drop under the bar to catch it in a deep-squat position." But Valle is not convinced that the existing research is applicable to elite weightlifters. "There is very little information."

Whatever the benefit, it appears to be limited

Regardless of what the data demonstrate, many weightlifters, particularly at the highest level, wear specialty shoes. As Schermoly pointed out, "If you're a top athlete, you want any advantage you can get." Valle, the consultant, shares that observation.

"The subjective feedback from athletes is that they feel it's not a luxury item, there's a reason that the athletes want to wear them and that's just the sense of security," Valle said. "It's a hard surface that they are pushing against. The feeling of stability that they gain, psychologically, there's something there, it's just comfortable."

Weightlifting shoes are not inexpensive. Schermoly said the shoes purchased for his study cost $100 for the "low-end" shoe and $200 for the "high-end" shoe. For a recreational weightlifter or person using weightlifting as part of a workout regimen, such an investment may not be worth the price for a specialized piece of footwear that may not be adaptable to other activities.

There are, however, other ways to replicate at least some of the feel and effect of a specialty shoe. Although most studies demonstrated no clear benefits to recreational weightlifters from elevating the heel, it likely doesn't hurt, and the elevation can be achieved in different ways. In Schermoly's study, athletes wearing athletic shoes raised their heels by resting them on a 2.5-pound weight disc; a 2017 study had athletes standing on a raised platform. [3] Niehaus recommends shoe inserts that elevate the rearfoot and add stability to the shoe. Schermoly notes that elevating the heel using a weight disc would not be effective for more active moves such as the snatch or clean-and-jerk.

Similarly, Niehaus recommends wearing the weightlifting shoes for weightlifting only. "Weightlifting shoes are designed to be worn specifically for weightlifting," she said. Although an athlete will be able to walk in a weightlifting shoe, they may be too stiff and heavy for other exercise.

Likely the only consistency among studies of the usefulness of weightlifting shoes is that more research and more standardization across the research is needed.

"The research on weightlifting shoes is limited with studies demonstrating varying results," Niehaus said. "The issue lies in the lack of high-level, head-to-head blinded, randomized studies. To my knowledge, there are currently no studies evaluating performance of the Olympic lifts in weightlifting shoes. Unfortunately, this is a difficult undertaking. It certainly would be an area worth exploring further." Such studies would require many participants and would have to control for all variables, from equipment to how the lifts are performed.

Valle notes that the true benefit of weightlifting shoes would come at the highest levels, where athletes are able to squat beyond 90 degrees. "When does it create benefit?" Valle asked. "Probably at the most extreme levels of depth. But most squat studies cut off where usefulness of weightlifting shoes may begin." ler

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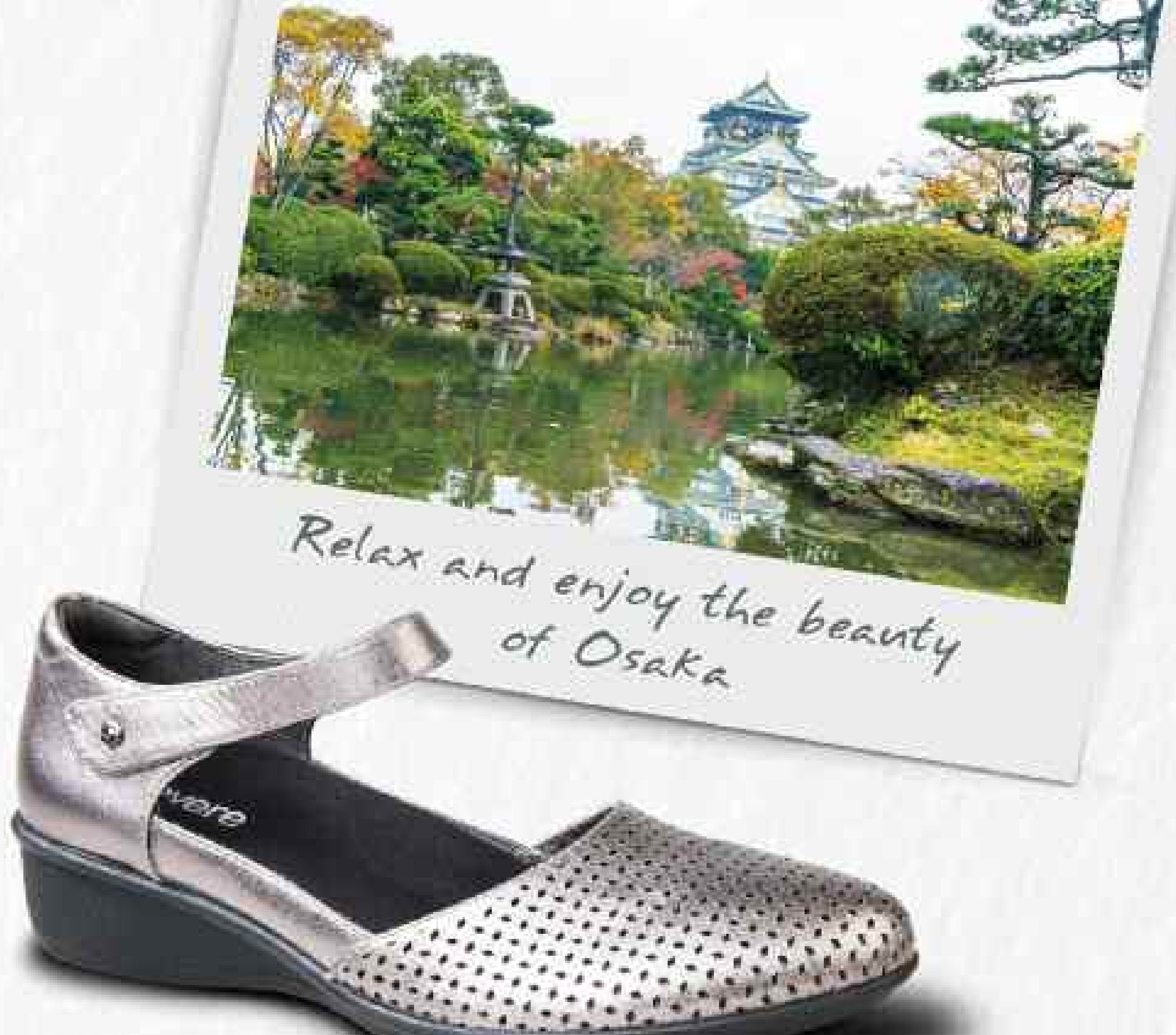

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Handler Mfg offers its improved 750A Sani-Vac dust collector. The unit incorporates new features intended to assist podiatrists, pedorthists, orthopedists, physical therapists, and their associates by saving time and provide safe material pickup. New features include a rigid but flexible stainless-steel hose for dust pickup. The shorter hose stays in position when adjusted. A remote foot switch enables easy on-off action. A more powerful vacuum motor allows for better material pickup (compared to the older 750 Sani-Vac). The unit features high-efficiency particulate arrestance filtration and easy filter change design. Sturdy casters are incorporated in the engineering for easy movement of the device. The casters also have a step-down design to hold the 750A in place.

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By Laura Hochnadel

Therafirm/Knit-Rite receive state award

Therafirm, Hamlet, NC, and its parent company, Knit-Rite, Kansas City, KS, received North Carolina's Top Rural Exporter Award, one of five awards sponsored by the Economic Development Partnership of North Carolina and presented by Governor Roy Cooper at a ceremony in the Governor's Mansion on January 31.

According to Therafirm and Knit-Rite, the award is the culmination of six years of working with the Economic Development Partnership to grow the company as a whole, and specifically exports. Products have been provided to customers throughout the world, including Mexico, China, Korea, Japan, Colombia, Argentina, and Canada.

The Economic Development Partnership is a public-private organization under contract with the North Carolina Department of Commerce that works with companies to grow business. "Working with the Economic Development Partnership of North Carolina has allowed us to visit countries and meet new customers we wouldn't have met otherwise," said Evan McGill, Executive Vice President of Business Development. "Their global knowledge and support for our company and our brands has allowed us to grow our export sales, hire new employees and increase our capital investment in Richmond County, while increasing our reach globally to approximately 50 countries and meeting the medical needs of thousands and thousands of new patients with our products."

PathMaker receives funding for noninvasive device development

PathMaker Neurosystems, Boston, MA, announced it has received a funding award from the New England Pediatric Device Consortium (NEPDC) to support development of PathMaker's MyoAmplifier™ system to treat paralysis and weakness due to damaged neuromotor pathways. The technology is an advanced noninvasive platform that integrates magnetic and electrical stimulation at cortical, spinal, and peripheral sites associated with targeted muscle. PathMaker Neurosystems is a clinical-stage bioelectronic medicine company developing noninvasive systems for the treatment of neuromotor disorders.

OIG to examine billing for OTS orthoses

The US Department of Health & Human Services Office of Inspector General (OIG) will examine the extent to which Medicare beneficiaries are being supplied certain off-the-shelf orthotic devices without visiting the referring physician within 12 months prior to their orthotic. The OIG also will analyze nationwide billing trends for 3 orthotic devices using data from 2014 to 2016.

The codes in question relate to devices billed under L0648, L0650, and L1833. L0648 and L0650 are lumbar sacral orthoses. L1833 is described as: Knee orthosis, adjustable knee joints (unicentric or polycentric), positional orthosis, rigid support, prefabricated, off-the shelf.

Billing for the 3 L-Codes has increased 97% and allowed charges have increased 116% representing $349 million in 2016. A Medicare Administrative Contractor (MAC) has identified improper payment rates as high as 79% for L0648, 88% for L0650, and 9% for L1833. Of concern to MAC is a lack of documentation of medical necessity in patients' medical records.

FollowKnee to develop 3D-printed artificial knee joints

Brest, France-based FollowKnee has been awarded a €7.9 million grant by the French national research agency to use 3D scanning and printing techniques to create a better artificial knee joint design and develop a new approach to production. The 3D printing will be conducted by Rennes, France-based SLS, known for producing ceramic dental fittings. The 3D-printed artificial knee joint will be constructed of a ceramic-metal alloy. The multidisciplinary project will also implement other cutting-edge technologies to address issues affecting replacement surgery, prosthetic devices, and the patient recovery process.

During the first 3 years of the program, 220 3D-printed prosthetic knee joints will be implanted by FollowKnee's team of surgeons. The surgeons will also implant approximately 30 sensors designed to track the condition of the prosthetic joint and detect any problems. Produced by CEA (French Atomic Energy Commission) Grenoble, these sensors will be used primarily in younger patients, allowing their performance to be tracked over a long period. Surgeons will use augmented reality to help plan the procedures and to implant the 3D-printed knee joints.

Agility Health to sell US assets

Agility Health Inc., Grand Rapids, MI, has agreed to sell 100% of its US-based assets to Alliance Physical Therapy Management, a wholly owned subsidiary of Alliance Physical Therapy Partners, Tampa, FL, a portfolio company of New York-based asset management firm GPB Capital Holdings. The arms-length transaction is valued at $45 million and was expected to close in February.

According to the purchase agreement, the company's subsidiary, Agility Health Holdings, and Alaris USA, will sell their respective membership interests in Agility Health LLC, the owner of the company's US-based assets, to Alliance. A portion will provide capital to grow Medic Holdings, Agility Health's Canadian subsidiary that will constitute the primary business and asset of the company post-transaction. Medic currently operates 12 outpatient foot care clinics across two provinces in Eastern Canada and manufactures orthotics and prosthetics.

Legislation: O&P clinician notes

The clinical notes of orthotists and prosthetists will again be recognized as part of a patient's medical record to determine reasonable and medical necessity of O&P devices—a change that was included in the bipartisan Continuing Resolution passed by Congress February 9. The provision is based on the Medicare Orthotics and Prosthetics Improvement Act of 2017, which set out to reverse a 2011 decision by the Centers for Medicare & Medicaid Services to no longer recognize those notes in an official capacity.

The same legislation includes a permanent repeal of the cap on Medicare outpatient therapy services, provides for changes to home health payments in 2020, and reduces payment for occupational therapy assistant services beginning in 2022.

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DJO to pay $7.62 million for subsidiary's "assumptive selling"

DJO Global (DJO), Vista, CA, has agreed to pay $7.62 million to resolve allegations that its now-defunct subsidiary, Empi, Shoreview, MN, submitted false claims to TRICARE for excessive, unnecessary transcutaneous electrical nerve stimulation (TENS) electrodes that TRICARE beneficiaries did not need or use.

The settlement resolves allegations that Empi used inappropriate techniques such as "assumptive selling" to persuade some TRICARE beneficiaries to seek and accept unjustifiably large quantities of TENS electrodes from 2010 through 2015, with a steep increase in the number of beneficiaries receiving unnecessary quantities in 2014 and 2015. Assumptive selling consisted of Empi sales representatives contacting some TRICARE beneficiaries and inducing them to order excessive TENS electrodes by acting as though the beneficiaries had indicated a need for them, when that may not have been the case. Empi has ceased operations.

APTA courses included in aPTitude CE resource

The American Physical Therapy Association (APTA) and the Federation of State Boards of Physical Therapy (FSBPT) have partnered to bring APTA's Learning Center continuing education offerings to FSBPT's online system, aPTitude. The site allows physical therapists (PT) and PT assistants to search for CE courses and track attendance. The system is available to state PT licensing boards, which can use aPTitude to evaluate CE compliance for purposes of licensure renewal.

PT licensure compact to begin mid-2018

The Federation of State Boards of Physical Therapy (FSBPT) has set mid-2018 as the go-live date for the Physical Therapy Licensure Compact, an agreement among member states to improve access to physical therapy (PT) services by increasing the ability of eligible providers to work in multiple states. PTs and physical therapist assistants will have available to them an expedited process for applying for licenses to practice in member state, and will also allow use of a telemedicine platform.

The compact went live in April 2017 with passage in a 10th state, triggering the creation of a Physical Therapy Compact Commission to develop final rules and bylaws, which were approved in December 2017.

AAOS welcomes chief education strategist

The American Academy of Orthopaedic Surgeons (AAOS) has appointed Anna Salt Troise as its new chief education strategist. In this role, Troise will direct all AAOS education and peer-reviewed publishing activities, as well as its newly implemented strategy.

Troise most recently served as vice president of medical and open access publishing at Wolters Kluwer where she managed the US, UK, and European medical journal publishing program. She also oversaw business activities for more than 150 proprietary and society medical journals as well as the editorial and business strategies for various medical societies. Prior to joining Wolters Kluwer, she held executive positions at Nature Publishing Group and John Wiley & Sons and has served as keynote speaker and panelist at various conferences within the publishing industry to discuss the trends and future of medical and academic publishing.

Podiatric coding expert Harry Goldsmith dies

Harry Goldsmith, DPM, a noted coding expert and consultant to the American Podiatric Medical Association (APMA) Health Policy and Practice department, died February 7. Goldsmith was instrumental in the development of the APMA Coding Resource Center, among other efforts that supported the APMA.

Goldsmith had nearly four decades of experience in coding, medical review, quality assurance, and practice management. A noted lecturer, he founded Codingline to provide expert advice in podiatric coding and billing. He was honored as the California Podiatric Physician of the Year in 2000 and was a member of the National Podiatry Hall of Fame.

PTAG honors legislator

The Physical Therapy Association of Georgia (PTAG) honored Senator Fran Millar (R-GA) with its Legislator of the Year Award on February 13 for his work to ensure all Georgians have access to physical therapy, reported Dunwoody, GA-based The Crier.

"Senator Millar has showed a continued commitment to PTAG's mission through his dedication to providing consumers with fair access to health care services," said Ryan Balmes, PTAG president. "We are extremely thankful for all his hard work and are especially grateful for his leadership on SB 164, which provides Georgians with more affordable access to health care through lower copays for physical therapy."

Fashion and inspiration for women

Trend-able.com, a fashion and lifestyle website that seeks to help women who have physical disabilities that require leg braces, orthotic or prosthetic devices or other devices such as for balance and walking to look and feel their best, is a free resource for patients, orthotists and prosthetists , and medical professionals available at http://www.trend-able.com The site aims to provide tools, fashion tips, and inspiration to women to live their best lives despite medical conditions and physical limitations.

Trend-ABLE founder Lainie Ishbia, who wears bilateral AFOs and struggles with fine motor tasks, says that many women with physical disabilities have poor body image and low self-esteem. Lainie knows from experience that a seemingly superficial concern, such as not being able to wear high heel shoes or button one's own shirt can affect how a person feels about her appearance and inevitably their health and general well-being.

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