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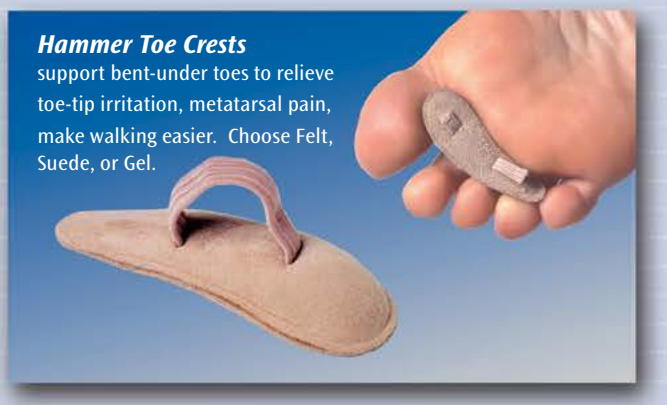

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Preferred Movement Pathway and Balance: How Proper Shoes and Orthotics Affect Athletic Performance

By Von M. Homer, MSc, BOCPD, PhD-c, Myles Starkman, DC, R. Christopher Mason, PhD, and Zeeshan Anwar, DPM


Von M. Homer, MSc, BOCPD, PhD-c


Myles Starkman, DC


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Zeeshan Anwar, DPM

'Good balance' is essential to athleticism. It is the common thread amongst all athletes on all levels. Balance or postural stability is also what separates leading elite athletes from other competitors. How well one's body generates balance is the major contributing factor to an individual's unique athletic ability. Balance also plays a significant role in allowing athletes to move at very high speeds in multiple directions on a variety of surfaces.

Proper footwear is essential for providing support for athletes while performing. A literature review in the *British Journal of Sports Medicine*[1] reports that more than 60% of the most common athletic foot injuries are directly associated with alignment issues. This is mainly due to the fact that clinicians and footwear engineers have not been successful at consistently providing subjective orthotic alignment modalities prior to dysfunction. Given the number of variables the body has to account for during a single athletic movement, it is almost inevitable that dysfunction from pathology will follow overuse. Functions such as speed, torque, and power are continually calculated by the body's nervous system based on proprioceptive feedback such as foot spatial orientation, pressure, and ground (athletic surface) contour; most of this organic feedback comes from mechanoreceptors in the skin and muscle of the foot.

Shoes are constructed to minimize organic feedback and replace it with inorganic footwear support that aims to absorb forces and protect feet from substantial injury. However, given that the nervous system calculates the center of pressure as being projected to the ground and not to the foot, postural stability is still at risk. While wearing athletic shoes, balance for athletes remains invariant because insole and outer sole composite materials change over time which subsequently results in postural instability and misalignment. Therefore, balance is subjective and is not predicated on a specific predetermined position: indeed, it can be achieved in numerous positions. We know that an upright weight-bearing stance requires two actions. The first action is maintaining support against gravity keeping the center of mass—a point that represents the average position of the body's total mass—at some height. The second action is maintaining balance by controlling the trajectory of the center of mass in the horizontal plane.

Controlling Motion and Mass

Neuroscience textbooks teach us that to maintain balance, the nervous system must control the position and motion of the body's center of mass, as well as the body's rotation around it. Meanwhile, as the force of gravity pulls on all body segments, it is opposed by the ground reaction force pushing up against the foot, which causes a net balance effect directly reflected through the center of mass. The net ground reaction force occurs at an imaginary point on the ground called the center of pressure.[2] Therefore, the location of the center of mass in the body is not fixed. It depends on the position and spatial orientation of the body as it moves.

There are multiple lines of thought as to how foot orthotics affect biomechanics. Concepts and theories of orthotics and biomechanics have been researched and utilized by clinicians for decades. The preferred movement pathway theory[3] hypothesizes that foot orthoses do not function by realigning the skeleton; rather, it argues that foot orthoses alter input signals through the plantar mechanoreceptors during the stance phase. These altered signals cause changes in the "muscle tuning" of the lower extremity, thereby producing a change in muscle activity with the goal of dampening soft tissue vibrations within the lower extremity muscles. Nigg proposed that if the foot orthosis counteracts the preferred movement path, muscle activity will be increased and cost energy; if the foot orthosis allows the joints/muscles of the foot and lower extremity to take their preferred movement pathway, muscle activity will be minimized, thereby increasing economy of movement and subsequently reducing the rate of overuse injury.

Most clinicians create foot orthotic devices based on the center of pressure being projected along the plantar surface of the foot. However, since the body is always in motion, even during static stance or standing, the center of mass continually moves about with respect to the base of support. Body imbalance or postural

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instability is determined by how fast the center of mass is moving toward the boundary of its base of support.

We also understand that human movement is stereotyped, which means that our central nervous system generates movement patterns that can be anticipated. These stereotyped movements are stimulated by peripheral changes in the support base such as stepping. Because countless patterns are stereotyped, most of the work of movement is done for us, so it is important to consider how movement is managed once it starts. A foot orthosis that works with the preferred pathway allows the nervous system to understand the surface under each step we take; this understanding is advantageous for mechanical efficiency, balance, postural stability, and injury mitigation; thus it is vitally important that we utilize the appropriate footwear and athletic equipment to stimulate the Preferred Movement Pathway.

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> Neuroscience textbooks teach us that to maintain balance, the nervous system must control the position and motion of the body's center of mass, as well as the body's rotation around it.

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Force and Pressure: Understanding Differences and Purposes

By Antonio Robustelli, MSc, CSCS

Whenever I talk about foot pressure-mapping technology during my courses or keynote lectures at international conferences, I am always surprised by the volume of misunderstanding that surrounds force and pressure measurements and questions about differences between them. While many of the answers seem obvious to me, I will try to clear up the topic in terms of both technology and biomechanics.

Force vs Pressure or Force + Pressure?

When talking about force and pressure values in biomechanics and sport science, it is important to note that they actually represent two complementary metrics and they can provide an in-depth insight into various aspects of performance as well as help in injury prevention and training individualization. In purely physics terms, force (F) represents a vector quantity, whereas pressure (p) represents a scalar quantity.

Force is one of the two most important kinetics quantities. As described by Knudson, it is "a straight-line push or pull, usually expressed in pounds (lbs) or Newtons (N)."[1] Force, which is the effect of an interaction between two bodies, is a vector with both size and direction.

Pressure, on the other hand, is defined as an external force divided by the area over which the force acts; it is expressed in pascal (Pa), corresponding to one Newton per square meter (N/m2). Unlike force, pressure is a scalar quantity because it has no size and no direction: it is the ratio between the normal force acting on a given surface and the area over which this force is applied. Pressure is not directed in a specific direction, so changing the orientation of the surface over which force is acting will cause a change in the normal force (the force acting at right angles to the surfaces of objects that are in contact) but not in pressure, which remains the same. This is the main difference between force and pressure from a biomechanical (physics) point of view.

A force is defined as a push or a pull that makes an object change its state of motion or direction. Pressure is a force spread over a certain area

Let's have a look at the differences from a purely practical and conceptual standpoint as well as clearing up how and why force and pressure are two complementary metrics providing different data output for analyzing performance.

Force and Pressure Measurement Technology

First, it is important to point out that pressure plates measure force indirectly, whereas force plates measure it directly. The technology behind force plates is relatively simple; it consists of a certain number of load cells measuring ground reaction forces and moments as a result of the force applied over the top surface of the plate.

Force plates can measure vertical forces only (single-axis platforms) or both vertical and shear forces (multi-axis platforms). Moreover, they can be unilateral or bilateral, depending if one needs to measure total forces being applied on the plate or forces for each limb separately.

Load cells measure force by monitoring variations in the electrical current when a force is being applied over them: the current flows through the sensors, which can be characterized by different types of transducers (strain gauge, piezoelectric, and piezoresistive, among others) that sense the variation in electrical current and this variation is converted into Newtons.

Pressure plates, on the other hand, directly

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measure pressure, surfaces, and time, where force is being indirectly calculated by summation of all the sensors' pressure values.

Unlike force platforms, pressure mats have a higher number of sensors (resistive or capacitive), usually ranging from 3000 in basic models to 16000 in high-end products. Also, they have a lower average frequency of acquisition (from 100Hz up to 500Hz). From a technological point of view, pressure mats are able to measure pressure whether by measuring variation in resistivity of a thin film that puts the sensors in contact with each other (resistive sensors technology) or by sensing the variation in electrical capacity between the surfaces of two films that are able to vary their distance and return to the starting point (capacitive sensors technology).

Data Output Differences

The main advantage of using both types of data is that one can have a clearer picture of what is happening in terms of force application into the ground and force transmission over the foot. In addition to the measurement of the total vertical force resulting from force plate testing, pressure measurement can provide a force measure for each of the individually loaded sensors on the mat, thus allowing for the division of the foot into regions of interest (rearfoot, midfoot, forefoot).

Segmentation of the foot, together with Center of Pressure (CoP) progression, is probably one of the most appreciated features of pressure mats: being able to isolate ground reaction forces and obtain force-time curves for each foot region represents a paradigm shift in performance analysis, injury prevention and return to competition evaluations.

Using both force and pressure measurements can help in making better decisions while providing a bigger picture of key performance parameters. ler

Antonio Robustelli is a professional sports performance consultant and elite coach from Italy; his areas of expertise include injury prevention, sports technology, strength training programming, speed development, recovery monitoring, and return to play assessment. He has worked worldwide for 16 years with semi-professionals, professionals, and Olympic athletes as well as professional teams in various disciplines. Regularly invited as a Keynote Speaker for international conferences in Sports Science and Strength & Conditioning, he is currently a consultant for Federations, Governing Bodies, Olympians and for First Division football and basketball teams in Europe, Asia, and USA. He is a member of the LER Editorial Advisory Board and can be reached at Antonio.robustelli@omni-athlete.com.

This article has been adapted from its original version of the same title, which can be found here https://www.omni-athlete.com/single-post/force-and-pressure-understanding-differences-and-purposes.

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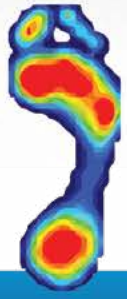

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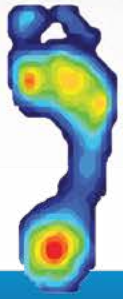

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AFOs and FES Offer Comparable Outcomes for Foot Drop in MS Patients

By Laura Fonda Hochnadel

Foot drop is a common presentation in people who have multiple sclerosis (MS). The inability to lift the forefoot off the ground adequately, such as to clear curbs and stairs, affects gait and increases fall risk. Ankle–foot orthoses (AFOs) and functional electrical stimulation (FES) are both used to treat foot drop. While AFO use is considered the usual form of treatment, a team of researchers from the United Kingdom found no previous studies comparing the effectiveness of the 2 devices in MS patients. Thus, they sought to compare the clinical and cost effectiveness of AFO and FES use over 12 months in this patient population.

Eighty-five people were randomly assigned to receive either an AFO or FES device; none had previously received either treatment. AFO prescription was based on recommendations made by the Best Practice Statement for AFO following stroke because no recommendations currently exist for AFO prescription in MS. The FES device used was the Odstock Dropped Foot Stimulator (ODFS) Pace.

Nine outcome measures were assessed, along with equipment and staff time costs of both interventions, at baseline and at 3, 6, and 12 months. Testing included 3 performance outcome measures and 5 patient-reported outcome measures (PROMs): the 5-minute self-selected walk test (primary), Timed 25 Foot Walk, oxygen cost of walking, Multiple Sclerosis Impact Scale-29, Multiple Sclerosis Walking Scale-12, Modified Fatigue Impact Scale, Euroqol 5-dimension 5-level questionnaire, Activities-specific Balance and Confidence Scale, and Psychological Impact of Assistive Devices Score (PIADS).

Regarding the performance-related outcome measures, the researchers noted that both groups walked faster with their device in the walking speed tests, although there were no significant differences between the groups at 12 months. Furthermore, although there was a significant change in oxygen cost over the 12 months, the groups also performed similarly in this measure. The FES group did, however, demonstrate a clinically significant ongoing orthotic effect for both walk tests, whereas the AFO group did not. These clinically significant effects are defined as ≥0.5m/s increase in walking speed.

The only difference between the groups' PROMs was noted in the PIADS, which was administered at 12 months only. The FES group scored significantly higher for the competence, adaptability, and self-esteem subscales, which may be due to patients viewing FES as a more acceptable treatment. The study authors further speculated that this might explain the greater attrition rate among the AFO group over the 12 months and result in better device compliance with FES. The research team also found FES to be a cost-effective treatment for foot drop in MS and, despite its higher initial cost, noted that it offers a viable economic alternative to AFO.

The authors conclude that in all aspects examined—clinical measures, patient-reported outcome measures, and financial analysis—FES and AFOs have comparable positive effects and both should be considered as feasible treatment protocols in MS patients with foot drop.

Source: *Renfrew LM, Paul L, McFadyen A, et al. The clinical- and cost-effectiveness of functional electrical stimulation and ankle-foot orthoses for foot drop in Multiple Sclerosis: a multicentre randomized trial. Clin Rehabil. 2019:33(7):1150-1162.*

Prevalence of Neuropathic Pain Symptoms

Managing pain in patients with foot and ankle pathology can be a challenge. In addition to nociceptive mechanisms, neuropathic mechanisms can contribute to pain in patients with orthopedic conditions and can be found

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in 10.5% to 53% of patients with chronic pain, depending on the location of the pathology. Neuropathic mechanisms include peripheral sensitization, central sensitization, reduced descending inhibition, and atrophy of cortical areas. Because preoperative diagnosis of neuropathic pain (NP) can impact therapeutic decision-making, researchers identified the need to understand the prevalence of NP in patients with foot and ankle pathology.

In this study of 533 mostly middle-aged adults, Philadelphia-based researchers used the painDETECT questionnaire to determine the presence of NP symptoms in patients with foot and ankle pathology. While the overall rate of NP symptoms was lower than previously published for hip, knee, and lower back, after sorting according to reason for surgery, they found a similar rate for patients with a history of foot/ankle surgery; significantly, they noted that this subgroup of patients had double the rate of NP symptoms compared to the native feet and ankle group.

Location played a role, with higher rates of NP symptoms in those with more proximal pathology. Rates of NP reported previously were 53% in those with lower back pain and 34% for knee osteoarthritis, compared to 12.4% in this study of patients with ankle and foot pathology. Even within the foot and ankle region, the rate of NP in the ankle and hindfoot regions was higher than the midfoot and forefoot (15.5%, 11.4%, and 7.5% for combined ankle/hindfoot, midfoot, and forefoot, respectively; see Table). The researchers did not find an explanation for this finding, but thought it was part of the peripheral sensitization mechanism and noted the fact that the more proximal the location of the pathology, the more nerves cross the area that can be sensitized.

Regarding the effect of preoperative NP on postoperative function and pain, these researchers suggest that a significant number of foot and ankle patients, both for acute injuries and chronic conditions, have NP symptoms. Based on these findings, a Visual Analog Scale pain level of >7 should alert the physician to check for NP. Similar to previous findings, they also found risk factors for NP symptoms, such as obesity, diabetes, smoking, pathologies in the ankle level, and prior surgery, though not a

Table 2: Neuropathic Pain According to Patients' Demographics, Medical History, and Their Foot and Ankle Pathology.[a]

	n	Neuropathic Pain	Nociceptive Pain	*P* Value
Male	205	25 (12.2)	180 (87.8)	1.00
Female	328	41 (12.5)	287 (87.5)	
Age, y, mean (SD)		49.7 (14.9)	48.7 (16.5)	.663
Risk factors				
DM	43	7 (16.2)	36 (83.8)	.466
Current smoking	56	13 (23.2)	43 (76.8)	.016*
BMI, mean (SD)		30.5 (6.0)	29.2 (6.2)	.113
BMI ≥30	223	35 (15.7)	188 (84.3)	.061
Workers' compensation	26	3 (11.5)	23 (88.5)	1.00
Previous surgery	98	19 (19.4)	79 (80.6)	.027*
Trauma	161	17 (10.5)	144 (89.5)	.47
Elective	372	49 (13.1)	323 (86.9)	
Ankle	246	38 (15.4)	208 (84.6)	.062
Hindfoot	57	9 (15.7)	48 (84.3)	
Midfoot	44	5 (11.3)	39 (88.7)	
Forefoot	186	14 (7.5)	172 (92.5)	
Soft tissue pathologies	429	52 (12.1)	377 (87.9)	.74
Bony pathologies	104	14 (13.4)	90 (86.6)	
Current pain (mean)		7.2	4.4	<.001*
Average pain (mean)		7.6	5.4.	<.001*
Strongest pain* (mean)		9.2	7.5	<.001*

Abbreviations: BMI, body mass index; DM, diabetes mellitus; SD, standard deviation. aValues are n (%) unless otherwise noted.

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higher prevalence of symptoms.

In conclusion, the authors encouraged clinicians to evaluate all patients preoperatively and take NP symptoms into account when deciding on an operative intervention and pain management both before and after surgery. While they found the painDETECT a good research tool, they advised that reviewing for allodynia, dysesthesia, rest pain, or radiating pain with every patient is a good clinical practice and should be sufficient.

Source: *Sidon E, Rogero R, McDonald E, et al. Prevalence of neuropathic pain symptoms in foot and ankle patients. Foot Ankle Intern. 2019, 40(6) 629–633; © 2019 by the Authors. Reprinted by permission of SAGE Publications, Inc.*

Orthotic insoles for people with diabetes at-risk of ulceration

BY ANA MARTINEZ-SANTOS, STEPHEN PREECE, AND CHRISTOPHER J. NESTER

This study focused on pressure-relieving orthotic insoles designed for retail footwear and people with diabetes and at risk of first forefoot ulceration. The aim was to investigate whether the pressure-relieving effects of a customized metatarsal bar and forefoot cushioning are sensitive to bar location and shape, and material choice.

Research design and methods: Patient-specific foot shape was used to design an orthotic insole, with metatarsal bar location and shape customized according to plantar pressure data. Changes in forefoot plantar pressure were investigated when 60 people with diabetes and neuropathy walked in 9 variants of the orthotic insole. These comprised 3 variations in proximal/distal location of the customized metatarsal bar and 3 different metatarsal head offloading materials.

Results & conclusions: The most frequent reductions in pressure occurred when the anterior edge of the metatarsal bar was placed at 77%

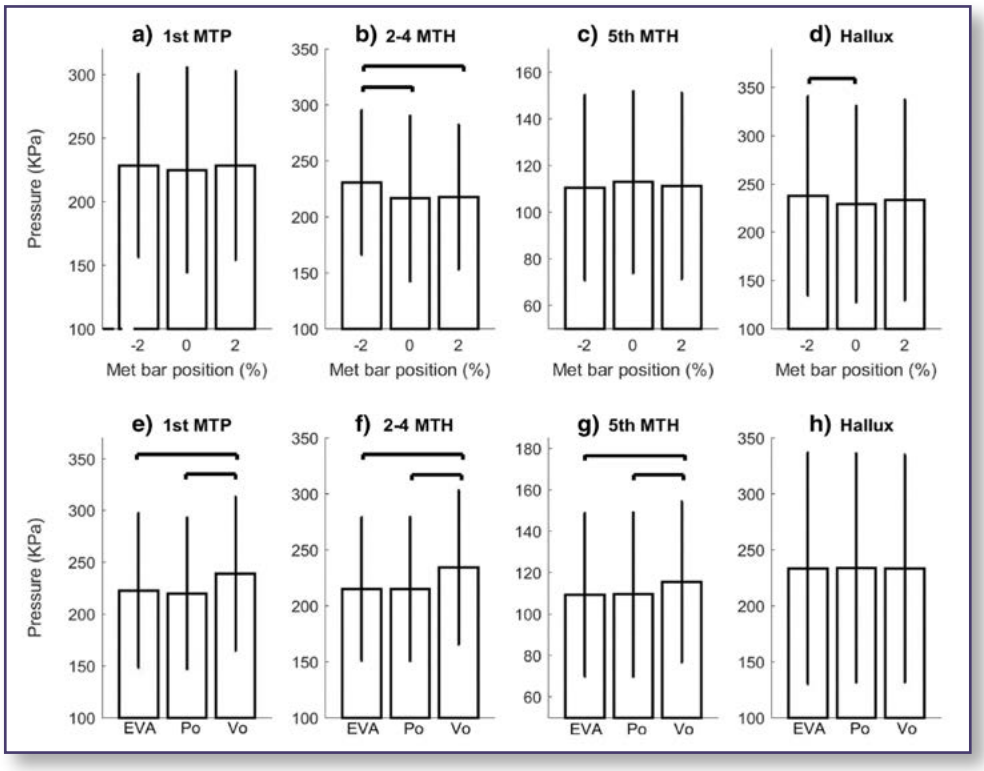

Figure. The effect of varying metatarsal bar location (a-d) and materials (e-h) on peak plantar pressures in the four different anatomical regions.
EVA = ethylene vinyl acetate. Po = Poron, Vo = void. Vertical lines = standard deviation. Horizontal lines indicate significant differences ($p < .05$ after Bonferroni correction)

of the peak pressure values, and its effects were independent of the choice of EVA or Poron offloading material (see Figure). In the flat insole, 61% of participants had 1 or more metatarsal head areas with pressure above the 200 KPa, reducing to 58% when adopting generic orthotic design rules and 51% when using the best orthotic insole of the 9 tested. Our results confirm that plantar pressure relief is sensitive to orthotic insole design decisions and individual patient feet.

Source: *Ana Martinez-Santos A, Preece S, Nester CJ. Evaluation of orthotic insoles for people with diabetes who are at-risk of first ulceration. J Foot Ankle Res. 2019;12:35. Use is per Creative Commons Attribution License. Full article is available at https://jfootankleres.biomedcentral.com/articles/10.1186/s13047-019-0344-z*

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Early Orthotic Intervention in Pediatric Patients, Part I
Cerebral Palsy

By Cary Groner

Children with cerebral palsy (CP) typically encounter a host of gait- and balance-related issues associated with spasticity, dyskinesia, and weakness. How severe these are depends on CP type and the individual case. As a result, experts have long debated how early to intervene with bracing strategies that include ankle-foot orthoses (AFOs), and how long to maintain those interventions. Increasingly, a consensus seems to be emerging that earlier intervention is a better strategy, as is long-term commitment to wearing an AFO. Even so, each child's situation is unique, and demands complex decision-making on the part of clinicians, orthotists, physical therapists, parents—and when they're old enough, the kids themselves.

Setting goals

"Many pediatric therapists might consider early intervention only up to age 5 years, but we should be talking about anywhere from 6 months on," said Elaine Owen, MSc, MCSP, a clinical professor and physiotherapist at the London Orthotics Consultancy in the U.K.

"Ideally, you'll have a list of goals," Owen continued. "Where do you want to be with this 1-year-old in 3 weeks, in 6 months? What do you want to achieve by age 2, 6, 10, 16? And how will those choices affect their life when they're 26, 46, or 76? Because whatever we do will affect their whole life, and how much pain they're in."

Pain, Owen noted, is one of the most significant indicators of quality of life, and because disabilities such as CP are often associated with lifelong pain, the choices made by care team members carry significant consequences, both physical and psychological.

"You have to set goals for the bones, the muscles, the brain, and for activity and participation," Owen explained. "And these goals also have to include just letting them be a child, because however they end up physically, they have to be psychologically balanced. We're still figuring out how to make the best orthotic decisions for each child, because it's different for a preschooler than for a 7-year-old. Most of us are trying to get a child to skeletal maturity at 16 with the least contracture deformity and the least number of surgical interventions." (See Goals of Therapy, page 25.)

Orthosis Design

For Beverly (Billi) Cusick, PT, COF, it's important that evaluation of a pediatric patient's gait includes a careful look at how they load their feet, medially or laterally. Cusick, who practices primarily in Telluride, CO, and has lectured at a number of healthcare educational institutions internationally, told *LER* that she focuses less on a patient's diagnosis than on what's going on biomechanically.

"There's a presumption that we know what AFO to order based on diagnosis, and it's just nonsense," she said, adding that it's crucial to

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

THE CASE FOR EARLY INTERVENTION

Early intervention to correct poor gait mechanics and alignment will help to prevent the development of contracture, weakness, and deformity. The more time a child spends walking with compensation, the more progressive their condition becomes. It only makes sense to intervene as early as possible. "You can't promote strengthening with poor movement patterns," said Scott Hinshon, CO.

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understand normal development in order to deal with children with CP and other disorders that affect gait.

"K.A. Ericsson said that achieving virtuosity in any skill takes 10,000 hours of practice," Cusick continued. She considers walking a virtuoso-level skill and points out that even normal kids take years to get it down.

"Infants build stability skills; they need to engage their limbs in learning and moving in all postures," she said. "Once they get to standing, they practice weight-shifting about 3,000 times an hour while they're just cruising with furniture. Then, as walking develops, they deal with body-weight distribution, which normally means more weight on the lateral than the medial column because this protects fragile ligaments from pronatory strains. That's when they gain strength and integrity."

To that end, Cusick recommends orthotic intervention for any CP child who loads the medial column more than the lateral, regardless of age.

"If a child looks good in solid cast boots, if his kinematics are good, and he's got control of posture and body weight in gait, then I say stay with them, or stay with the solid AFO that behaves most like a cast boot," she said. "You can introduce degrees of freedom later—6 months, a year, whenever you think it's necessary—to let them have a little plantar flexion but still keep control of dorsiflexion."

One of Cusick's mentors, the late pediatric physical therapist Mary Weck, included strengthening exercises for her patients' feet and lower legs, Cusick explained. Weck continued the children in solid AFOs until the foot didn't pronate through push-off, then weaned them from the orthotics and used night splints until their skeletal growth was complete.

"They maintained control of equinus and full function up to 14 years after the casting course," Cusick said. (According to the unpublished data, the average was 5.6 years.) "It's not about how long it takes, it's about how you get there."

Scott Hinshon, CO, who is CEO of both Orthotic Care Services and LaunchPad O&P (a manufacturer of AFO optimization components) in Minneapolis, agreed that biomechanics take precedence over diagnosis, at least to a point.

"It's helpful if I understand their diagnosis, but their clinical presentation is going to drive the orthosis design, and that in turn is based on goals," he said.

Gait Mechanics

"For a spastic patient, if you can't influence where the knee is in space as it's traveling through stance phase, you can't normalize gait," Hinshon said.

For Hinshon, the point is to evaluate the patient globally, from the foot to the head. Many of his patients have weaknesses in the core, in the quadriceps, and in gluteals that affect downstream biomechanics.

"Proximal compensations create distal symptoms," he said. "Some people try to adjust alignment of the foot and ankle with an SMO (supramalleolar orthosis) instead of treating the sagittal plane compensations at the ankle, the knee, and the hip. As a result, they're not optimizing the patient's mobility or potential for rehabilitation."

GOALS OF THERAPY

There are three main categories of goals: Alignment, Functional and Rehabilitative.

1. Alignment

- Neutralize foot and ankle alignment (pes planovalgus)
- Neutralize knee alignment (crouch and recurvatum)

2. Functional

- Establish heel strike (loading response)
- Control descent of foot at loading response
- Normalize foot alignment at second rocker to prevent postural deformity
- Maintain plantar grade foot position through stance phase (early heal rise, vaulting, toe walking)
- Reduce anterior trunk lean
- Maintain straight foot projection angles (in-toeing, out-toeing)
- Improve tibial progression (10 degree shank-to-vertical angle)
- Increase single limb stance time and control
- Increase contralateral step length

3. Rehabilitative

- Increase cadence
- Improve endurance
- Encourage normal development
- Encourage independent ambulation
- Encourage proximal strengthening
- Restore dorsiflexion range of motion
- Restore knee extension range of motion

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> "We know that a spastic muscle is a weak muscle. The question is how to address that weakness."
>
> **Kathy Martin, PT, DHSc**

CP patients, he acknowledged, are among the most difficult to manage.

"They're internally rotated, they're trying to advance, their mass is in front of their feet, they're leading with their head, and their arms are out because they're ready to fall," he said. "Often they have compensations related to mobility, alignment, and limited range of motion in the joints. They have to learn how to move over this device, and they'll take longer to normalize their gait than those who have low tone."

It's important to recognize that change takes time and you need patience and persistence with the process, Hinshon said.

"Our care protocol is evaluation, then fit a week or 2 later, follow-up 2 weeks after that, then more follow-ups at 1 month, 2 months, and so forth. I think about orthotics as a process of care rather than a device, because if you do your job well, those kids will change really quickly." Hinshon noted that even though his company produces a range of adjustable orthoses, he and his staff are strong proponents of solid-ankle AFOs if they offer a given patient the best prognosis.

"The brace doesn't restore range of motion in the ankle," he said. "It's improved gait that restores both ROM and strength."

Nicole Brown, DPT, who works in developmental and rehabilitation services at Children's Hospitals and Clinics of Minnesota, frequently collaborates with Hinshon on patient care. She agreed that CP patients present special challenges.

"They have the tonal [spastic] influence, but typically with an underlying muscle weakness," she said. "Our goal is to get them to use more muscle strength. In patients with a crouch gait, the muscles with the most tone are the adductors, hamstrings, and plantar flexors; so as those muscle fibers are lengthening, they'll kind of catch. If you don't have the strength to keep that leg moving, you're going to stop, and that tone will hold your muscle fibers in place. That's why they step down with knee flexion and femoral internal rotation. So we do significant strengthening programs with them in a solid AFO."

Kathy Martin, PT, DHSc, a professor in the Krannert School of Physical Therapy at the University of Indianapolis, agreed.

"We know that a spastic muscle is a weak muscle," she said. "The question is how to address that weakness. If the child has voluntary control, then we have a shot at getting them stronger, but if they don't, we're going to have to compensate with some kind of rigid support."

Cusick concurred. "Solid AFOs have a tremendous place in management," she said. "They are far more effective at teaching children how to load their foot and move over it than articulating devices."

She added that in this context, tibial inclination—sometimes called shank-to-vertical angle (SVA)[1,2]—is critical to patients' achieving more normalized gait .

"For me, the decision to use solids over others has everything to do with that," she said.

Relevancy of Shank-to-Vertical Angle

Professional disagreements about the best way to measure SVA have led to confusion among practitioners. Briefly, Owen supports measuring from the anterior tibial border, whereas Hinshon usually aims for the mid-sagittal line, from the fibula head to the lateral malleolus. Cusick also prefers using the fibula and noted that because this approach yields slightly different numbers, it's important that clinicians not mistake these as equivalent to Owen's figures.

Hinshon noted that optimal angles vary between patients, in any case.

"For one child it might be 8 degrees; for another 10 or 11 degrees. You have to evaluate the function and quality of the gait, and the measurement simply validates your success or failure. It's really only important if you're not achieving your functional goals." (See Post-Fit-

POST-FITTING OPTIMIZATION TIPS

1. Focus on the knee during in-brace ambulation
2. Set shank-to-vertical angle with heel lifts to ensure tibial progression between second and third rocker
3. Focus on foot projection during brace ambulation
4. Normalize foot projection (rotation straps, check shank-to-vertical angle, forefoot posting, adjust posterior stop)
5. Note cadence for future comparison

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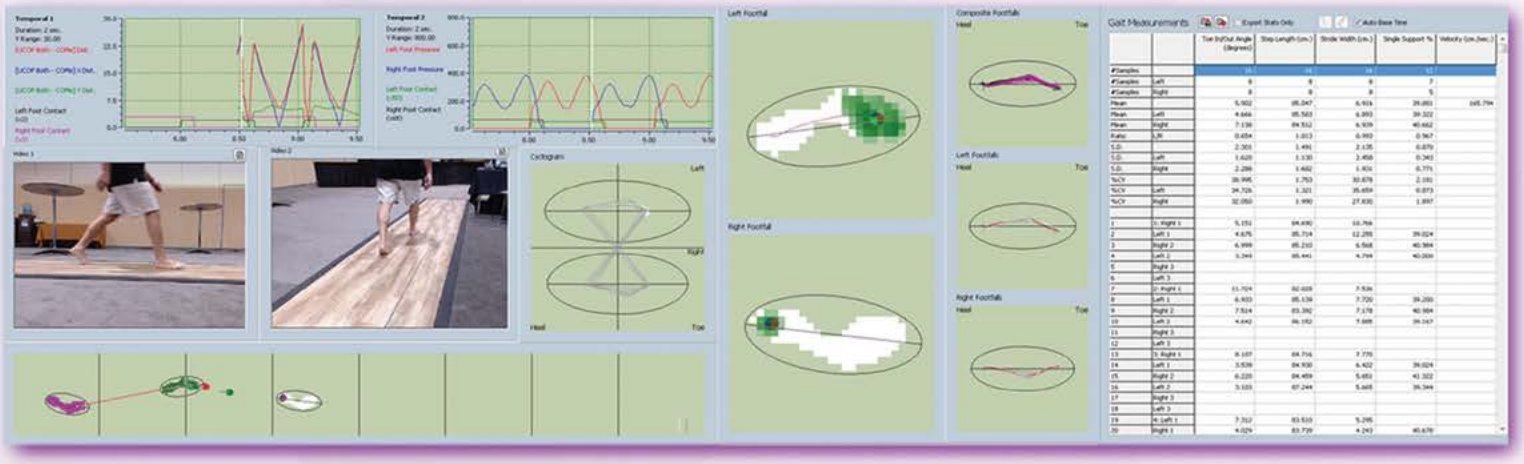

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ting Optimization Tips, page 28.)

"It doesn't really matter where you measure it from," added Owen. "It's just that when people report their results, they need to state which measurement they used so accurate comparisons can be made. Tuning is about getting the most normal walking for the best prognosis ."

Tuning

LER has covered AFO tuning in past issues.[3] According to Owen, tuning an AFO involves an optimization of static alignment to influence shank and thigh kinematics, so that during stride the shank passes through vertical and reaches an incline of roughly 10–12 degrees at midstance.[2] Ideally, this enhances stability; improves sagittal plane kinematics; helps align ground reaction forces (GRFs) relative to the knee and hip; and may contribute to energy conservation.[4] A well-tuned AFO also improves rocker function.[2]

Shoes are an important part of the tuning equation, as well—so much so that clinicians often use the term AFO-FC, for "AFO-footwear combination."[3] Studies support the efficacy of this approach in treating gait deformities in pediatric CP patients.[5,6]

> "Tuning is about getting the most normal walking for the best prognosis"
>
> Elaine Owen, MSc, MCSP

"If I'm going to optimize the gait of a CP patient, I have to anticipate what's going to happen to the knee extension moment at heel strike, at initial contact, and at terminal stance," explained Hinshon. "We use plantar flexion stops and heel lifts to get our shank angles where they need to be."

Most clinicians would agree that pediatric patients present with stance-phase related issues. The majority of Hinshon's patients have the greatest need at midstance to late stance. He discovered that tibial resistance was the best way to manage pronatory foot postures and to generate power in late stance that enhances step length, improves single-limb stance stability and increases cadence.

"To manage knee compensations, we use dorsiflexion stop motion for crouch presentations and dorsiflexion resistance for recurvatum. The resistance prevents fall-off at the knee and promotes tibial progression." Hinshon continued, "Contrary to common belief, recurvatum is best treated with dorsiflexion resistance, not plantar flexion stop motion. This is why I invented X-tension bands, there just wasn't any product on the market that would provide the resistance I needed."

The Method

Owen has developed a comprehensive approach to evaluation and treatment. A chart summariz-

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> "Once they get to standing, they practice weight-shifting about 3,000 times an hour while they're just cruising with furniture"
>
> **Beverly (Billi) Cusick, PT, COF**

ing her method contains 4 columns for tracking issues with:

- bones, joints, and ligaments;
- musculotendinous units (MTUs) and skin;
- neurological control and developmental mobility; and
- functioning.[7]

Under the first column head, readers will find a detailed breakdown of strategies to manage deformities. The second column describes ways to address abnormal neuromuscular function, including compensation for weak MTUs and controlling the effects of MTU hyperactivity. The third deals with standing and walking kinematics as well as the quality and development of gait patterns. The fourth primarily addresses posture, balance, and social interaction.

Owen told *LER* that she always tries to involve the parents—and to the extent possible, the child—in the consultation and treatment process.

"I ask the family to talk to me about their worries, what they want to get better," she said. "I write everything down in those 4 columns on a board, we'll add in things the clinical team may be concerned about, then we'll see if an orthosis is the best option. Based on all that, we set goals."

Starting when the children are young can prevent extensive surgeries later, and when the parents realize this, they usually become enthusiastic about bracing options.

"You just walk them through it," Owen continued. "Let's start with the column with the bones. If you want your child's feet to look like normal adult feet, you've got 7 or 8 years to get there, and that means considering orthoses, often a fixed-ankle AFO. Once the parents have the information, and they become an equal partner in the process, they come to the same conclusion."

Hinshon acknowledged that it can take work to help parents understand that the more quality in-brace steps patients can take, the more likely they are to achieve their goals. "There is a direct correlation between compliance and outcome. You can't expect 'full time' results with a 'part time' wear schedule."

Owen believes in balancing physical and psychological goals but noted that they're usually compatible.

"You get kids through life addressing both their physical condition and their emotional state," she continued. "I think the most important thing is for them to end up psychologically well, but that doesn't mean ignoring their physical disability. You might decide that they need to wear the orthoses only 60% of the time—so then, what 60% will that be? You negotiate. If the child wants to dance and the AFOs hinder them, take them off. If they can't dance without them, leave them on. Once you have your overall goals, you just have to decide on the right orthosis for the right amount of time. Over the years, the negotiations become much easier because the child learns to trust you." ler

Cary Groner, a freelance writer in the San Francisco Bay area, has been writing about biomechanics for LER for 10 years.

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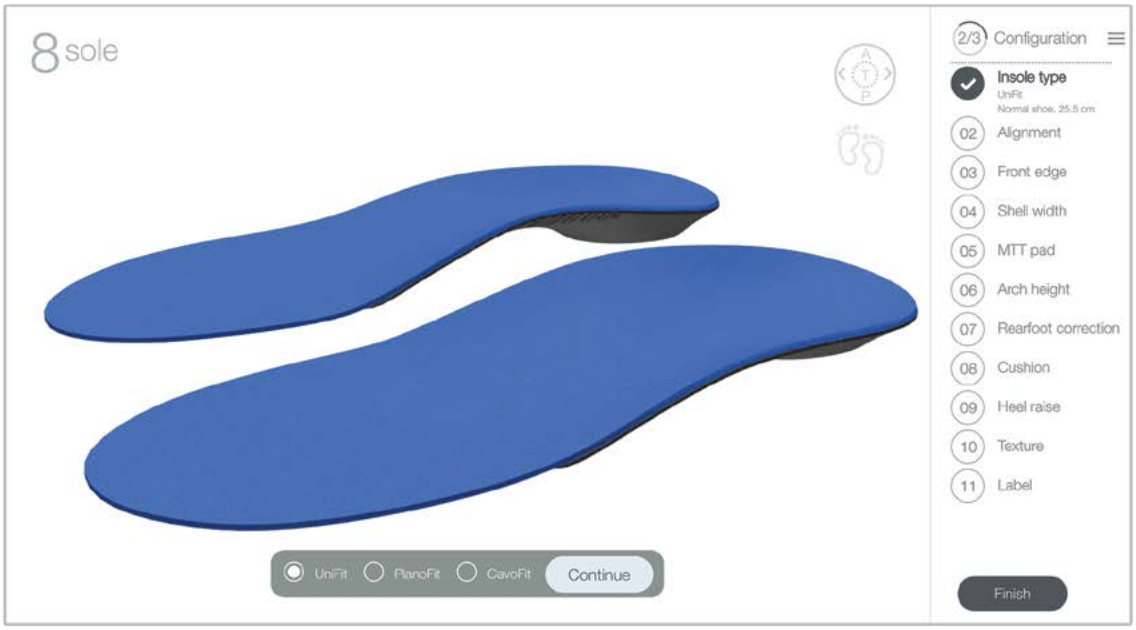

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Pregnancy Changes the Body: Here's What That Means for Gait, Balance, and Falls

About a quarter of women fall during pregnancy and 10% fall more than once. Understanding the biomechanical changes of this transitional period may help researchers find ways to prevent such falls.

By Nicole Wetsman

When Robert Catena's wife was pregnant and working at a restaurant, she fell. It was scary, he says, but everything was ok. One of her co-workers, though, also fell, and wasn't so lucky: she had severe complications with her pregnancy. Soon after, Catena, a PhD researcher who studies kinesiology and biomechanics, started a new position at Washington State University—and decided to direct his research toward studying balance control in pregnant women.

"Falls are second only to motor vehicles when it comes to injuries caused to pregnant women," Catena says. About a quarter of women fall during the course of their pregnancies, according to conservative estimates; such falls pose a considerable risk to both the fetus and the pregnant woman. Around 10% of women report falling more than once. The rate is close to the rate of falls in the elderly.[1]

However, falls aren't often discussed as risk factors for this population. Pregnancy comes along with a host of physiological changes, but research into the way those changes affect balance, gait, and other biomechanics are limited. Efforts to push the field forward, though, could help reduce fall risk in pregnant women.

Balance and stability changes

Women undergo a series of physical and hormonal changes during pregnancy, including weight gain around the abdomen, increased joint laxity, due to changes in levels of the hormone relaxin, increased force on joints, and increased pelvic tilt. Among other things, those changes affect the way women stand, walk, and move through the world—and may contribute to changes in their balance, which can increase the likelihood of a fall.

For some time, common wisdom suggested one of the major factors leading to balance and movement changes was the shift forward of a woman's center of gravity as her stomach and abdomen expanded outward to account for a growing fetus, Catena says. "People believed that was the main contributor to why balance was changing," he says. But recent research complicated that standard narrative. "We've found the center of gravity doesn't explain as much as we thought."

In a study published in the *Journal of Applied Mechanics* in 2019,[2] Catena and his team tracked 15 pregnant women starting from around 12 weeks into their pregnancy—performing motion captures, recording anthropometric measurements, and conducting walking balance tests, among other measures, every 4 weeks through the course of gestation. They found that the women's balance dropped steadily as pregnancy progressed, and that individuals with poor balance prior to pregnancy had the worst balance during pregnancy. However, they found that anthropometric changes to the body and body mass had little relationship with changes and deficits in balance during pregnancy. "We didn't see a lot of explanations for the variance there. That was interesting," Catena says.

Walking balance decreases over the course of pregnancy, as well, Catena found in a 2018 study published in the journal *Gait and Posture*.[3] His team tested 12 women on a treadmill over the course of pregnancy and classified walking balance and potential for fall as the movement of their center of mass relative to the borders of support on their feet. Walking speed decreased as pregnancy progressed, which corresponded with anterior-posterior motion, as did the women's ability to stay in the center of the treadmill while walking. Step width increased

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HOW OFTEN, WHERE DO PREGNANT WOMEN FALL?

In a population-based study of 3997 women who had given birth within the past 2 - 7 months, women were asked to report injuries that occurred during the prenatal period, the mechanism and timing of the injury, as well as part(s) of the body injured. Specifically related to falls:

- 1070 (27%) reported falling at least once
- Of those 1070
  - 35% reported falling 2 or more times
  - 20% reported seeking medical help
  - 21% had 2 or more days of restricted activity as a result

Where did they fall?

- 56% fell indoors
- 36% fell on stairs
- 9% fell from ≥3 ft (not mutually exclusive)

Data from Harland KK et al. Risk factors for maternal injuries in a population-based sample of pregnant women. J Women Health.2014;23(12):1033-1038.

They found that the women's balance dropped steadily as pregnancy progressed, and that individuals with poor balance prior to pregnancy had the worst balance during pregnancy

Continued from page 33

during the second trimester of pregnancy.

Women have differences in postural stability as they progress through pregnancy, according to a study published in the *Journal of Biomechanics* in 2010.[4] This study compared 81 women, 41 who were pregnant and 40 who were not pregnant. The participants stood on a force plate and their movements and reaction times were measured in response to movement in the plate. There were no differences between pregnant women in their second trimesters and women who were not pregnant; but in the third trimester, pregnant women had less sway in their movements than those who were not pregnant. That finding was contrary to the initial hypothesis, says study author Jean McCrory, PhD, and associate professor in the department of human exercise and physiology at West Virginia University.

"The more advanced they were when we perturbed them, the less movement they had," she says. "We thought we would see more." There were a number of reasons for that hypothesis: pregnant women have more of the hormone relaxin, which should make them more lax, and it should take their reflexes longer to kick in. In addition, because they have more mass, the researchers would expect it would take longer to control.

"My theory is that they are adapting to these slower reflexes by co-contracting," McCrory says. "They're not normally standing and waiting for something to perturb them. They're already contracting their muscles, so that they're much more rigid, and they're prepared. They might have adapted to having slower reflexes that way."

In future studies, she plans to use electromyography to measure lower leg muscle response to displacement in pregnant women, in order to determine if they are in fact adapting to slower reflexes in that way.

McCrory was also the first characterize what she calls the "pregnant waddle:" the distinctive side-to-side gait women walk with during pregnancy.[5] Kinematic data collected on 29 pregnant women and 40 women who were not pregnant found that women had a wider stance in their third trimester. The data, published in 2014 in the *Journal of Biomechanics*, also showed that they exhibit more lateral movement during gait.

"We think it's intuitive to widen your stance when you're not feeling stable," McCrory says. "Because you have this massive belly, the body shifts leg to leg rather than bending, because it doesn't bend so much anymore ."

Increasing fall risk

To identify the characteristics of women who fall during pregnancy, McCrory collected data on a cohort of pregnant women and asked them to report if they did or did not fall. Of the group that remained in the research until it's conclusion, 15 fell and 14 did not fall during their pregnancy. They were tested twice: once in the second trimester and once in the third trimester. Forty women who were not pregnant served as the control group and were tested once.

One study of this cohort, published in 2014 in the journal *Gait and Posture*,[6] used anthropometric data and data from a motor control test, where subjects were placed in a harness as they stood on a dynamic plat-

form. Pregnant subjects who were fallers had smaller center of pressure–center of gravity values, indicating that they were less able to make corrections in response to shifts in the platform. Pregnant subjects who were non-fallers had more ankle stiffness than those who fell. Increasing ankle stiffness—through exercise or bracing—could therefore be a strategy for reducing falls, the study concluded. Tracking center of pressure–center of gravity values in pregnant women may also serve as a way to identify women at risk of falling.

Another study measured the subjects as they climbed and descended a four-stair staircase, collecting data on their stance, speed, ground reaction forces, and center of pressure. Stance and speed were consistent between pregnant fallers and non-fallers. Pregnant fallers had a larger braking impulse while climbing stairs and a smaller propulsive force when descending stairs, which the study notes might be due to more caution. They also had a larger minimum between vertical peaks during both ascent and descent.[7]

One of the most interesting data points in the faller and non-faller cohort, McCrory says, is that all of the women who reported that they were sedentary during pregnancy—who didn't do any exercise—were fallers. Not every woman who exercised was a non-faller, but more than half of exercising women were non-fallers. "I think exercise is really important," McCrory says. "Maybe it helps you adapt to a changing body. If you're moving more, you learn how it's different. If you do encounter a hazardous situation, like water on the floor or a curb, you don't fall. That was a surprising result. In the small sample, exercise seems to be important." In some pregnant women, exercise might not be recommended, due to other complications. "As long as it's not contraindicated, exercise prevents so much, like gestational diabetes and other problems. But it also looks like it really might prevent falls."

Assessing Fall Risk

Research into the characteristics of pregnant women who both do and do not fall is important to help develop ways to predict which women are at risk of falling, and of ways to counteract that risk.

"Our drive is really to come up with a fall risk assessment of some kind," Catena says. "How do we differentiate one person from another? Not every pregnant woman is the same, and not everyone will experience the same changes in balance and in walking."

As well as biomechanical causes, Catena's team is looking to "attention" as a potential factor in fall risk. "Pregnant women might be focusing attention internally, and not necessarily paying as much attention to the external environment," he says. They're also looking into strength and endurance changes. "Anything that might cause the inability to sense how the joints are positioned in the lower extremity."

Increasing awareness of falls, both for doctors and for pregnant women, is a key element of improving safety.

"I don't think falls are even on their radar," McCrory says. "They don't slip on ice. For the most part, women fall in their homes, or at work. In my

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study, they only remembered because they had a form to fill out. I think there are more women falling—they just don't remember, because they don't get hurt. If they do get hurt, though, it can be disastrous."

At the moment, many clinicians aren't talking with their patients about falls. "They tend to be very general, and ask if you've experienced a fall, and use that to determine if you're likely to have another one," Catena says. "That makes sense, with what we have now. But we don't want them to experience the first fall."

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GRADUATED COMPRESSION STOCKINGS EFFECTIVE IN REDUCING VARICOSE VEINS IN PREGNANCY

This prospective controlled randomized clinical trial was conducted to evaluate the effect of compression stockings in the prevention and control of varicose veins in the lower limbs of pregnant women. Prior studies using ultrasonographic tests had shown that the Great Saphenous Vein (GSV) diameter was higher in pregnant women not using compression stockings than those in the intervention group.

This study population included 60 women who were recruited 10 – 15 weeks into their pregnancy; had a CEAP classification of 0, 1, 2, or 3; and were aged 18-40 years. All were white and had normal pedal or tibial posterior pulses. Clinical evaluations and Duplex-ultrasound were performed by 2 qualified examiners in 120 lower limbs of the 60 pregnant women in 2 periods: between the 10th and 13th and between the 30th and 33rd week of gestation. The study protocol included examination of the deep and superficial venous system; the GSV and SSV in the thighs and legs were mapped and analyzed.

Women in the intervention group (n=30) received 3 pairs of compression stockings (20-30 mmHg; BASIC style, Sigvaris Inc., Peachtree City, GA) and were told to wear them for 8 hours/day. The stockings were correct for ankle and calf diameters and height of the leg (measured from the calcaneus to the knee). Biweekly telephone calls were used to monitor regular use of the stockings. Women in the control group were treated with standard of care.

Results: Great saphenous vein diameters in the intervention group were 0.37 cm initial and 0.32 cm final ($p<0.0001$) in the right leg and 0.28 cm and 0.38 cm ($p<0.0001$) in the control group. CEAP classification presented worsening in the control group ($p<0.0001$). The signs and symptoms reported in the control vs. intervention groups: pain (86.67% vs. 23.33%; $p<0.0001$), edema (70.00% vs. 33.33%; $p=0.0045$), and leg heaviness (93.33% vs. 13.33%; $p<0.0001$).

Worsening of the CEAP classification in the control group included progression to CEAP classes 4 and 6, with significant changes in skin and one active ulcer. Women in the intervention group appeared to remain stable until the end. Pain in the lower limbs, the most common symptom of varicose veins, was also highly prevalent in the control group, yet was least prevalent in the intervention group. Furthermore, the reduced prevalence of all symptoms in the intervention group is indicative of the effectiveness of the therapy.

The authors noted that all women in the intervention group reported that they felt an improvement of symptoms in the legs and that they would use the compression stockings again. These findings mirror those of others who observed that acceptance of the stockings was associated with regular use, and regular use was associated with patients' improved quality of life.

In this study, the prescribed compression stocking had a compression of 20–30 mmHg, and reflux at the end of the research were noted in 0/30 patients in the intervention group and 16/30 patients in the control group, findings similar to Thaler et al and to Uhl's study using computed tomography. The reduction of venous diameters suggests that this therapeutic protocol was effective in the control of varicose veins and the relief of undesirable signs and symptoms of edema, pain, and heaviness in the lower limbs which occur frequently during pregnancy.

In conclusion, the authors noted that patients who used the compression stockings had reduced GSV and SSV diameters, improved signs and symptoms of venous insufficiency in the lower limbs, and were highly satisfied with the use of compression stockings.

Source: *Saliba Junior OA, Rollo HA, Saliba O, Sobreira ML. Graduated compression stockings effects on chronic venous disease signs and symptoms during pregnancy. Phlebology. 2019; May 1:268355519846740. [Online First]*

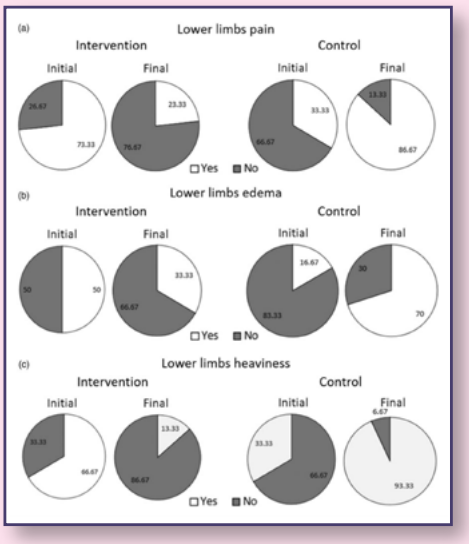

Figure. Percentage distribution of pregnant women in the intervention and control groups based on the pain (a), edema (b), and heaviness (c) in the lower limbs at the beginning and end of gestation (Botucatu, São Paulo, Brazil, 2017).

Healthcare Provider-Implemented Foot Evaluations for Walking Exercise Programs

Encouraging exercise and appropriate footwear selection may be key in helping patients maintain healthy activity levels.

By Audris Tien, DPM, Brad Franklin, DNP, RN, FNP-C, FAANP, and Jarrod Shapiro, DPM, FACFAOM, FACFAS

LER is pleased to partner with the American College of Foot & Ankle Orthopedics & Medicine in providing peer-reviewed content for a multidisciplinary audience.

Exercise is recommended for the majority of patients regardless of age, gender, or physical disability. The 2008 Physical Activity Guidelines for Americans1 recommended that all adults perform 150 minutes per week of moderate aerobic physical activity or 75 minutes of intense physical activity per week to achieve a cardiovascular benefit. The World Health Organization corroborates this recommendation for the worldwide adult population.[2] Healthcare organizations across the globe support adult exercise recommendations to mitigate the risk of weight-related disease and disability, which is epidemic in the industrialized world. Healthcare providers should be advising patients to exercise.

To ensure patients can exercise safely, practitioners should provide a thorough foot evaluation and evidence-based recommendations on footwear selection. The purpose of this article is to help healthcare providers recognize the components of a proper foot exam, understand the different types of shoes and shoe anatomy, and provide direction to patients in the selection of footwear products.

Literature Review

The rationale for such a broad worldwide consensus on the recommendation for exercise is the need to reduce the incidence of obesity and the diseases that follow. Currently, 34.9% of all US adults are classified as obese (BMI > 30), with another 35 % classified as overweight (BMI 25 – 29).[3] Type II diabetes mellitus (T2DM), the disease most often associated with excess weight, is occurring in epidemic proportions with 9% of US adults affected.[4] Worse, more than 1 in 3 US adults have prediabetes, a condition caused by excess body weight and lack of exercise. Worse still, the incidence of T2DM among those under 18 is increasing. Once T2DM develops, negative impacts on health include macrovascular (ie, cardiovascular disease) and microvascular (ie, retinopathy, neuropathy) complications. Many consequences of obesity are reduced or preventable with a combination of weight loss and exercise. Despite the benefits of exercise being well known, only 21% of adults report reaching the minimum amount recommended by the 2008 Physical Activity Guidelines—that's only 1 in 5.[5]

While the barriers to adequate exercise are multifactorial, convenience, accessibility, and cost play a major factor for many adults.[6] Helping patients understand that exercise comes in many forms and tailoring the language to each patient is essential for making exercise recommendations. Generally, exercise recommendations that are simple and easy to complete will improve patient compliance. Walking is a simple exercise that allows nearly all patients to meet the recommended targets. It is an easy way to be physically active and is a normal part of everyday life for most adults. Walking is inexpensive, practical, and generally a convenient form of exercise that can be done in nearly any setting. And importantly, walking is the only aerobic exercise that is considered safe for previously sedentary patients, making it ideal for those patients with comorbidities.[7]

The benefits of walking have been fre-

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quently studied and may surprise many patients and providers alike. Overall, walking improves cardiorespiratory fitness if performed at least 150 minutes per week, typically 30 minutes 5 times a week.[8,9] Walking has also been shown to improve lower extremity muscle strength and decrease body weight and body fat in middle-aged obese women.[8] Plus, it is associated with a decrease in the decline of bone loss in young and old women, even those with osteopenia.[10,11] In men, walking has been associated with a decrease in all-cause mortality, even in those with comorbidities.[12] For patients with T2DM, walking up to 150 minutes per week improves fasting blood glucose, hemoglobin A1c (HbA1c), and triglycerides.[13] Even standing or walking for as little as 5 minutes after prolonged sitting can reduce post-prandial glucose levels and insulin secretion, which can help with prediabetes.[14]

Younger patients appear to have additional reductions in total cholesterol and low-density lipoprotein cholesterol (LDL-C) values compared to elderly patients.[8,13] Sedentary adults can also show reductions in diastolic blood pressure even if they do not have a history of hypertension. Even patients with chronic musculoskeletal pain show improvement in both pain and activities of daily living with a regular walking routine.[7]

Although making the recommendation to exercise is straightforward, the actual implementation by the patient can be challenging. Typically, the responsibility for selecting appropriate footwear falls on the patient—often without the benefit of receiving a recommendation from a provider. Most often, patients select athletic footwear based on consumer concerns versus foot form and function. Poor-fitting footwear may lead to injuries that can prevent patients from obtaining the recommended amount of exercise. Healthcare providers, by conducting a foot examination, are in a valuable position to help patients select the appropriate footwear.

Lower extremity injuries due to poor-fitting footwear have been well documented. In a recent study of older adults, Menz et al.[15] reported that up to 50% wore shoes that were too narrow or too short, which resulted in corns, toe deformity (hallux valgus), or foot pain. In the Veteran population, patients with diabetic foot wounds were more likely than not to have poor-fitting footwear.[16] Even among active US military personnel, one study showed that up to 56% wear shoes that are sized inappropriately.[17] That same study reported that up to 70% of runners develop an overuse injury[17], making the shoe selection critical, and the foot evaluation even more important. Healthcare providers can help prevent lower extremity injuries by performing a foot evaluation that helps the patient select appropriate footwear for their exercise program.

Table 1: Essential Components of Foot Exam

Vascular

- Does the patient have palpable dorsalis pedis and posterior tibial pulses?
- Is capillary refill to the digits less than 3 seconds?
- Is there pedal/digital hair growth?
- Is there a temperature difference between the right and left foot? Or between the calf and the foot?

Dermatology

- Does the patient have any areas of discoloration, redness, or swelling?
- Are there any areas of hypertrophic skin or calluses? If so, where, and how many?
- Does the patient have open wounds or fissures?
- Does the patient have any signs of venous disease: hemosiderin deposits, varicosities?
- Inspect the nails for signs of fungal disease or ingrowing toenails.

Musculoskeletal

- Does the patient have full range of motion of the ankle and subtalar joint?
- Does the patient have the expected passive and active muscle strength?
- Does the patient have any musculoskeletal deformities?

Neurologic

- Is the patient responsive to light touch sensation?
- Does the patient respond to Semmes-Weinstein monofilament test or Ipswich touch test?

Foot Examination Components

A complete and thorough foot exam has 3 components: the patient history, the physical exam, and patient education.

The history-taking portion of a patient encounter is often the most time-consuming yet most telling portion of the exam. When the chief complaint is related to the patient's foot, questions regarding onset, duration, provoking and relieving factors, and prior treatment need to be explicitly asked. Information on changes in shoe gear or increased physical activity should also be ascertained. When enough information has been gathered to garner a list of differential diagnoses, the provider may move onto the physical exam to home in on the most likely diagnosis.

Much like a full physical, the components of a complete foot exam can be broken down into various health systems: vascular, dermatology, musculoskeletal, neurological. No matter which systems component is examined first, a systematic order should be followed. Table 1 outlines the essential components of a complete foot exam.

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The vascular exam includes palpating for the dorsalis pedis and posterior tibial pulses. The dorsalis pedis pulse can be palpated lateral to the extensor hallucis longus tendon on the dorsal surface of the foot. The posterior tibial pulse can be easily palpated posterior to the medial malleolus. It is also important to check capillary refill of the digits, with normal capillary refill being <3 seconds. The presence or absence of pedal hair growth is also indicative of circulatory status to the lower extremities. Temperature differences between the left and right foot or between ipsilateral calf and foot should be noted too.

The dermatology exam can be done concomitantly with the vascular exam, paying close attention for signs of venous disease which may manifest as varicosities, hemosiderin deposits, or brawny, atrophic skin. Additionally, the location and number of calluses should be documented as calluses are signs of high-pressure areas that may predispose to ulcerative lesions. Increased warmth and edema may also indicate signs of an acute inflammatory response following a musculoskeletal injury. Interdigital spaces should also be checked for any debris or maceration because deeper lesions often go unnoticed due to the folds of the skin. Nails should be inspected for signs of fungal disease, in-growing or elongated toenails.

The musculoskeletal exam should include basic muscle strength testing against resistance in all four quadrants—dorsiflexion, plantarflexion, eversion, and inversion—as well as passive and active range of motion of the ankle joint and subtalar joint. Pain and crepitus with range of motion of joints may indicate symptoms of osteoarthritis. Musculoskeletal deformities, such as hammer toes or bunions, can increase patients' risk for ulceration and should be charted and monitored.[18] Determining foot type is recommended with the patient standing, as natural muscle tone will create the appearance of an inverted foot with high arch in most feet except those with rigid flatfoot, such as patients with osteoarthritis.

Discussion of a complete biomechanical exam is beyond the scope of this review. However, general components of this exam are pertinent to assisting with shoe choices. The general foot type, including pes planus, pes cavus, or rectus appearance (Figure 1), is important when choosing a shoe. More rigid foot types, for example, generally better tolerate cushion shoes, as described below. Next, hammertoes may require a shoe with a deeper or wider toe box to accommodate these deformities. Most significantly, hammertoes with primarily sagittal plane contractures are poorly tolerated by common shoes and may need increased depth or softer materials for the shoe upper. Additionally, the position of the heel in the frontal plane is important for shoe tolerance. An inverted (varus) heel may cause increased friction on the posterosuperior aspect of the calcaneus, potentially causing abrasions.

Figure 1. Footprints indicating three general types of feet. From left to right: the cavus foot type shows minimal arch contact with the ground; rectus foot type shows somewhat more midfoot contact with the ground; and the planus or pronated foot shows a significant amount of arch contact with the ground.

The neurological exam consists of testing the Achilles tendon reflex and light touch sensation, as well as protective sensation using the 5.07 Semmes-Weinstein monofilament (SWMF) in those at risk for peripheral neuropathy, such as patients with diabetes. There are 10 points to examine using the SWMF with the patient's eyes closed, as depicted in Figure 2; inability to feel at least 7 of the 10 spots indicates loss of protective 102 sensation (LOPS). The Ipswich Touch Test (IpTT) is a simple alternative neurologic test that requires only the provider's index finger. During the IpTT, the patient is instructed to close his/her eyes while the provider lightly rests his or her index finger on the patient's first, third, and fifth toes for a few seconds. Patients are instructed to respond "yes" every time they feel the provider's light touch. Two or more insensate areas are indicative of peripheral neuropathy based on this test. In a trial conducted in 2011, the IpTT was found to be equally sensitive and specific to the SWMF test.[19]

Patient education is a critical component of the office visit as it serves to inform the patient about their diagnosis, manifestations of the disease process, and allows them to take an active role with the treatment team; engaged patients often are more adherent to recommendations and treatment options. This part of the visit gives healthcare professionals the opportunity to equip patients with the knowledge needed to allow them to take control of their foot care and report any new findings of pain, swelling, lesions, or discoloration.

Foot Type and Shoe Selection

All patients who begin a new exercise program should consider the importance of appropriate shoes. In many cases, incorrectly chosen or worn out shoes may be the cause of considerable injury. Improper shoe wear has been implicated in a host of lower extremity complaints including hallux valgus (bunions), hammertoes, plantar fasciitis, and hindfoot pain, in both children and adults.[20-23] Because of the import-

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ant contribution shoes have on foot health, it behooves healthcare providers to understand shoe anatomy.

Basic shoe anatomy may be best described in terms of the Oxford dress shoe (Figure 3). The standard shoe consists of the top portion of the shoe, called the upper, and the bottom of the shoe, called the sole, which is generally broken into three parts: the outsole, midsole, and inner sole. The outsole is the part of the shoe touching the ground, while the midsole is sandwiched between the outsole and the upper. The innersole is generally the inside part of the shoe touching the foot. Many shoes will also have a "sock liner" or removable insert.

The various parts of the shoe upper include:

- the toe box (the front aspect of the shoe where the toes sit),
- the throat (the portion that rises onto the top of the foot, generally where the laces are located),
- the vamp (the section between the throat and the toe box),
- the quarter (essentially, the sides of the shoe), and
- the heel counter (the curving aspect at the back of the shoe that holds the heel).

The shoe may additionally contain padding and decorations for comfort or style. Shoes are generally manufactured from a pre-made mold, or last, which determines the shape of the shoe. Shoes are generally available as straight- or curved-lasted (Figure 4). The shape of the shoe will have significant effects on fit and function and may affect some patients' pre-existing pathology.

When educating patients about shoes it is helpful to simplify the many available choices into the following three options:

1. Neutral shoe – midrange stiffness and cushion with few additional components built into the shoe. A neutral shoe may be recommended for patients with a rectus foot type—those who do not overpronate (roll too far inward) or supinate (roll outward). The neutral shoe has equal amounts of cushioning and stability to help absorb shock.

Figure 2. Semmes-Weinstein Monofilament foot test locations.

Figure 3. Anatomy of a standard shoe.

2. Motion control shoe – also called "anti-pronation" shoes, has additional components, such as internal stiffeners and heel wedges, to prevent excessive foot pronation during walking. These shoes are most appropriate for patients with planus foot types because built-in components, such as stiffer heels, counter the excessive motion seen in over-pronation.

3. Cushion shoe – provides extra shock absorption for walking and tends to be more flexible throughout the shoe upper and sole. Cushioned shoes are recommended for those with cavus feet to compensate for the poor shock absorption of a high-arched foot.[24]

It is important to understand, though, that the foot is a highly complicated anatomical

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structure that does not always conform to these general rules and we recommend consultation with a podiatric foot and ankle physician whenever patients present with foot pain.

Characteristics of Good Footwear

The choice of appropriate footwear is a highly subjective process. However, some objective characteristics of quality shoes may be made. Shoes should be sized correctly, with a snug, but not too tight fit. The shoe should be made from quality materials to prevent premature breakdown. A quality shoe typically has a removable insert that is not glued to the insole. Determination of shoe stability is also essential prior to wear. We recommend three simple tests to assess the quality of the shoes and appropriate foot support provided. Figures 5A-C demonstrate these tests and show examples of a poor-quality shoe (page 48).

Recommendations on Buying Shoes

When purchasing new shoes, various factors should be considered to optimize fit and decrease the chance of foot, leg, back pain, or injury. We make the following recommendations to patients to find the "right fit" (see Table 2).

Implications for Practice

Implementing a walking program clearly has many benefits for overall patient health. Making the appropriate footwear choice will contribute to preventing shoe-related foot problems and keep patients healthy. Healthcare providers are ideally suited to provide a thorough foot examination and make appropriate footwear recommendations for their patients who start walking exercise programs. ler

Table 2: Summary of recommendations for buying shoes

1. Buy shoes at the end of the day.
2. Fit shoes with socks worn during that activity.
3. Fit shoes to the larger foot.
4. Measure feet every time new shoes are purchased.
5. Children should buy shoes the exact size and not to grow into.
6. The widest part of the shoe should correspond to the widest part of the foot.
7. Try on shoes with orthotics.
8. Wear shoes at least 10 minutes before buying.
9. Shoes should feel comfortable immediately (no break-in period).
10. Avoid narrow toe-box shoes.

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Figure 4. Example of a straight lasted shoe. Note the lack of curvature or "C" shape in the outsole of this athletic shoe.

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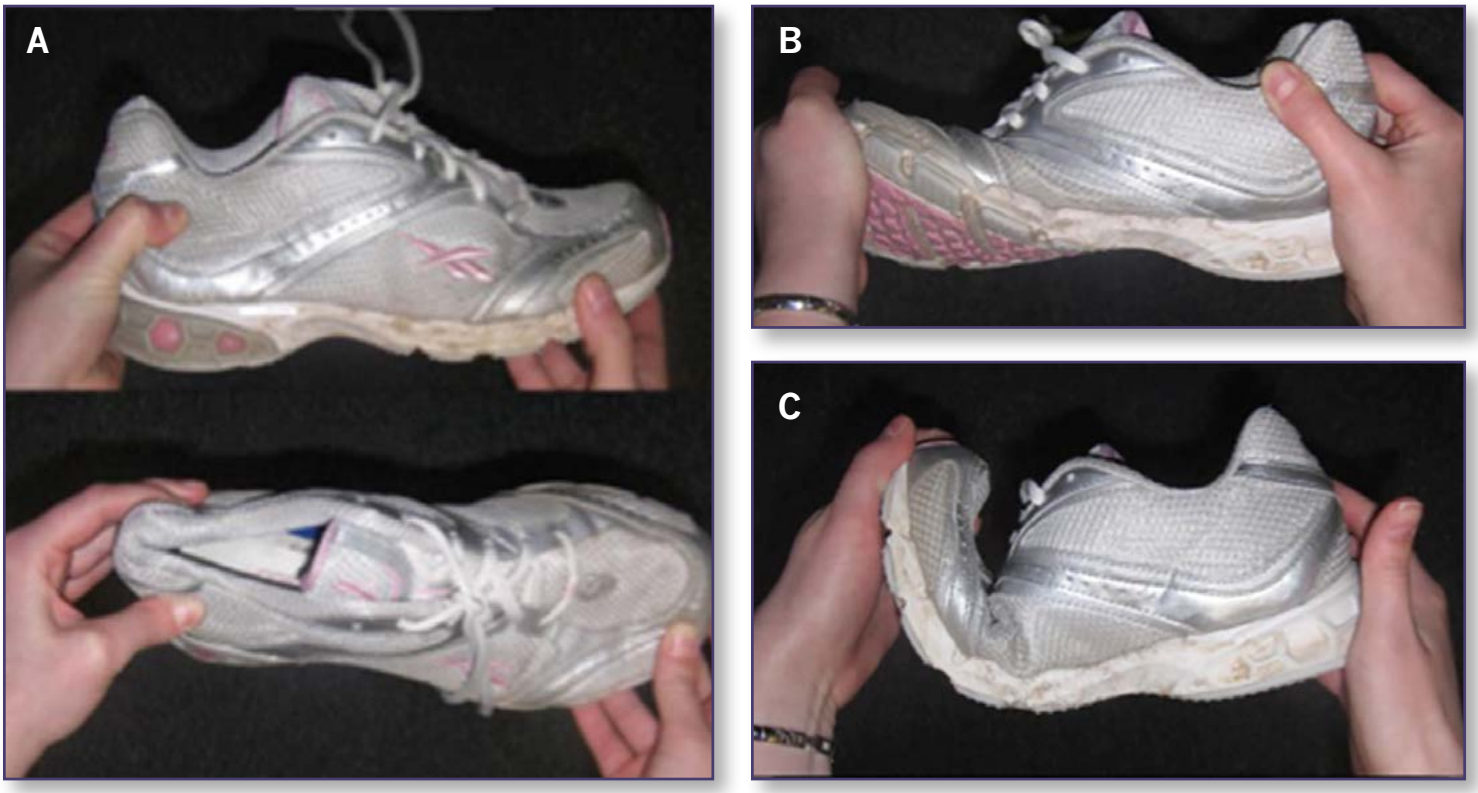

Figure 5. Tests to determine shoe stability. **A.** Shoe counter test. Squeeze the lower portion of the shoe counter. A quality shoe will not allow the counter to collapse inward. **B.** Shoe torsion test. Holding the heel counter and toe box, attempt to twist the shoe. A quality shoe will not allow significant twist. **C. Flex test.** Attempt to compress the anterior aspect of the shoe with the posterior part. A quality shoe should allow the vamp to bend only at the same location the toes would normally bend and nowhere else. Additionally, further compression of the shoe should not occur.

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Chronic Ankle Pain? Put Os Trigonum Fracture in the Differential

This overlooked, often-left-undiagnosed ankle pathology causes long-term pain and instability. Appropriate treatment protocols, applied in a timely manner, can get patients back on their feet.

By Scott Pensivy, PT, LAT, ATC

The ankle presents an interesting dichotomy of strength and frailty: Whereas the ankle supports body weight, makes sharp twists and turns, and keeps the body from falling, it simultaneously can be frail and susceptible to sprains, strains, and even fractures from simple movements, such as stepping off a curb, or drastic trauma, such as stepping into a hole while running at full speed.

The healing process seems simple: namely, the RICE principle—rest, ice, compression, elevation—with possible ankle bracing or taping while performing activity. However, not all ankle trauma follows this roadmap to recovery and healing: When an ankle continues to demonstrate pain for longer than the typical healing time after the original diagnosis, misdiagnosis might be an issue, and other pathologies need to be considered—in particular, as I describe here, fracture of the os trigonum.

What Is It?

The os trigonum is an elongation of the posterior aspect of the talus, located at the posterior aspect of the talus and lateral to the flexor hallucis longus tendon. Usually an extension of the posterior talus process, it has also been identified as a separate process.

The prevalence of os trigonum has varied widely in the literature; based on newer findings, it is more common than once thought:

- A 2019 study of computed tomography (CT) scans of the ankle in 586 Chinese patients found an incidence of 27%.[1]
- In a 2018 study of CT scanning of 1256 ankles (628 patients with 665 symptomatic ankles), os trigonum was found in 30.3% of the entire cohort[2]; furthermore, nearly 24% of unaffected ankles were marked by the condition, making it far more common than previously reported.
- In a small subset of cases without impingement in the same 2018 study, prevalence was about the same (30%).[2]

The first appearance of an os trigonum is commonly at approximately 9 years of age; it has been seen in children as young as 7 months. In rare situations in older adults, the bone is fused to the calcaneus or both tarsal bones.

Repetitive Microtrauma Leads to Chronic Pain

Because fracture of the os trigonum is rare, the condition can be misdiagnosed, which can lead to chronic pain, instability, diminished function in the ankle, and other upper-kinetic-chain injuries. (See "Case: longstanding ankle pain in a ballet dancer," page 52.)

A patient with an os trigonum fracture typically has chronic ankle pain or chronic ankle pain that does not completely resolve. A plantarflexion inversion sprain is the prime mechanism for acute fracture of the os trigonum, accounting for nearly 85% of cases.[3] Often, these cases are misdiagnosed and treated as a typical lateral ankle sprain.

Once the os trigonum escalates into a chronic problem, consistent ankle pain does not resolve with protocols used to treat a lateral ankle sprain and pain; surgery might be required. When the fracture results from traumatic ankle sprain, damage can also occur as the os trigonum gradually separates from the talus, due to repetitive microtrauma. Such injuries are typically the result of weakness, overuse, or poor mechanics. (Consider what happened to a 15-year-old competitive ice skater who is a patient in my practice: Because she would jump in the rink for hours at a time, she eventually suffered microtrauma of the os trigonum. Her diagnosis was os trigonum fracture, or traumatic ankle repetition microtrauma.)

Continued on page 52

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How to Identify an Os Trigonum Fracture

Physical evaluation. Subjectively, a patient's increased pain during palpation of the posterior medial ankle, just posterior to the medial malleolus, can make the examining clinician aware of underlying ankle pathology. In addition:

- Pain can be present when the ankle is passively in an equinus or valgus position.
- Because of the relationship of the flexor hallucis longus to the os trigonum area, a patient can also experience pain with active or passive dorsiflexion or contraction of the flexor hallucis longus, and increased pain upon plantarflexion.[4]
- A patient might have crepitus, local ecchymosis, or pain, or a combination of these findings, in the retrocalcaneal space.
- Additionally, there might be weakness in weight-bearing upon plantarflexion on the involved side.

Imaging. Once objective and subjective values have been collected, the clinician should obtain a lateral ankle plain film to confirm or rule out a fractured os trigonum. A positive fracture site is marked by separation and a rough, jagged edge in the region of the os trigonum (Figure, page 54). Smooth areas on the radiograph are a sign that there is no fracture.

In some patients, a nuclear bone scan can determine the integrity of the osseous components and also verify the diagnosis. The best test for revealing osteolytic pathology is a CT scan; getting insurance coverage for such a procedure is another story. Some orthopedic surgeons also inject lidocaine, 1.2 cc, into the os trigonum area. If symptoms disappear or change for the positive, this can confirm the fracture.

Surgical Intervention and Rehabilitation

When a fracture of an os trigonum is caught early, a short-leg cast might handle the problem; if the condition becomes chronic, however, surgical intervention might be the only avenue to full recovery. Factors that lead to surgical intervention include:

- severe antalgic pain
- decrease in function
- pain
- effusion
- decreased range of motion
- inability to perform a particular activity that one wishes to (eg, a professional dancer or basketball player who needs to spring off the ankle without limitation).

Technique. Surgical intervention involves taking a lateral approach to the ankle. The incision is made posterolateral to the lateral malleolus. The sural nerve in the peroneal tendon needs to be identified and carefully avoided. The os trigonum is identified and excised by the surgeon with additional exploration to rule out any other further osteolytic problems in the area.

Postop imaging. Postsurgical radiographs are taken. The patient is sent for rehabilitation with an experienced physical therapist, at which time a second radiograph is taken to rule out any hidden osseous lesions or other fragments.

Rehab. The physical therapy protocol consists of evaluating and treating the patient for 4 to 6 weeks, addressing effusion, gait, function, strength, range of motion, proprioception, and kinesthetic awareness, all while managing pain. Ankle protocols include progressive resisted exercise and dynamic and functional activities.

Treatments can include iontophoresis, phonophoresis, electrical stimulation, blood-flow restriction, massage, cupping, dry needling, and acoustic waves. During the first week of rehabilitation, activity of the flexor hallucis longus is minimized; single toe-ups are usually contraindicated because this maneuver irritates the affected region.

Continued on page 54

CASE: LONGSTANDING ANKLE PAIN IN A BALLET DANCER

A 25-year-old professional ballet dancer presented with a complaint of a 6-year history of chronic left ankle pain. Initial onset was caused by a severe plantarflexed inversion sprain that she sustained while performing. The pain alternately increased and diminished over those 6 years, but never disappeared. She reported having a high tolerance to pain, and dancing through the ankle pain.

Recently, a moderate lateral ankle sprain left her nonfunctional and incapacitated. She complained of left ankle pain, effusion, and decreased function that did not resolve. After several weeks of a conservative treatment protocol elsewhere, the pain, dysfunction, and instability lingered.

During initial evaluation in our facility, the patient also complained of lateral ankle pain. A pronatory foot-type presented with a closed kinetic compensatory forefoot and rearfoot valgus deformity with moderate adductor hallucis valgus of the first ray. Decreased range of motion was noted in active plantarflexion and passive dorsiflexion. Pain increased with ankle valgus and equinus. Passive dorsiflexion exacerbated the pain in the posterior ankle region of the os trigonum. The patient reported that the pain was greatest while taking the calcaneus and passively forcing it caudally and superior, a move specifically meant to activate the os trigonum region.[1]

The patient ambulated with an antalgic gait with decreased midstance on left, with a compensatory rearfoot and forefoot valgus and minimal toe-out. She had minimal-to-moderate effusion in the posterior area just medial to the medial malleolus. She stated that radiographs were reported as unremarkable.

The patient was given a prescription to be treated for lateral ankle sprain and was placed on a lateral ankle protocol for 1 month.

A month later, the patient reported minimal improvement—not significant enough to allow her to return to the demanding schedule of a professional dancer. This ankle sprain was judged not to be following a normal healing pattern for an ankle sprain diagnosis. The physical therapist recommended a second opinion by an orthopedic foot surgeon.

The surgeon ordered a bone scan and a CT scan, which revealed a lateral ankle sprain and obvious fracture of an os trigonum. He recommended surgery and performed an os trigonumectomy 2 days later.

Nine weeks later, after a full course of physical therapy as described above, the patient returned to full dancing activity with the ballet company—without pain or restrictions.

Recovery in this case was hindered by a late diagnosis. The lesson to be learned? Timely and appropriate diagnosis enhances a patient's rehabilitation potential; as we were often taught in school, "Treat the cause, not the symptoms."

Reference

1. Russell JA, Kruse DW, Koutedakis YI, McEwan IM, Wyon MA. Pathoanatomy of posterior ankle impingement in ballet dancers. Clin Anat. 2010;23(6):613-621.

Continued from page 52

The patient should be evaluated for possible pronatory foot caused by eccentric contraction of the flexor hallucis longus tendon. If this problem is identified, the therapist can use tape to help stabilize the joint by decreasing pronation and enhancing supinatory motion. Stabilizing the joint allows it to rest, relieves pain, and decreases excessive forces to the region of the os trigonum.

Taping is a good first test before ordering a custom orthosis. If the taping technique relieves pain, a prescription for an orthosis might be helpful. If the patient has significant forefoot and rearfoot compensated valgus, a custom orthosis should definitely be considered. If the joint is in a pronatory state, taping prevents eccentric contraction of the flexor hallucis longus from entering into the midstance in a concentric contraction of pushing off with a forefoot and rearfoot compensated valgus posture.

Other treatments and modalities that enhance healing include cryotherapy, paraffin, and aquatic therapy. I have had patients with a fracture of the os trigonum in postop rehabilitation who do extremely well using an underwater treadmill or the AlterG antigravity treadmill (AlterG, Fremont, Calif.). In my practice, I have also seen blood-flow restriction work to enhance metabolic activity or hacking the metabolic system to improve healing groundwork. ler

Scott Pensivy, PT, LAT, ATC, is President, Pensivy Sports Medicine Institute, and founder, PT ProCare, both in Las Vegas, Nevada.

Figure. Plain film reveals a rough, jagged edge to the os trigonum.

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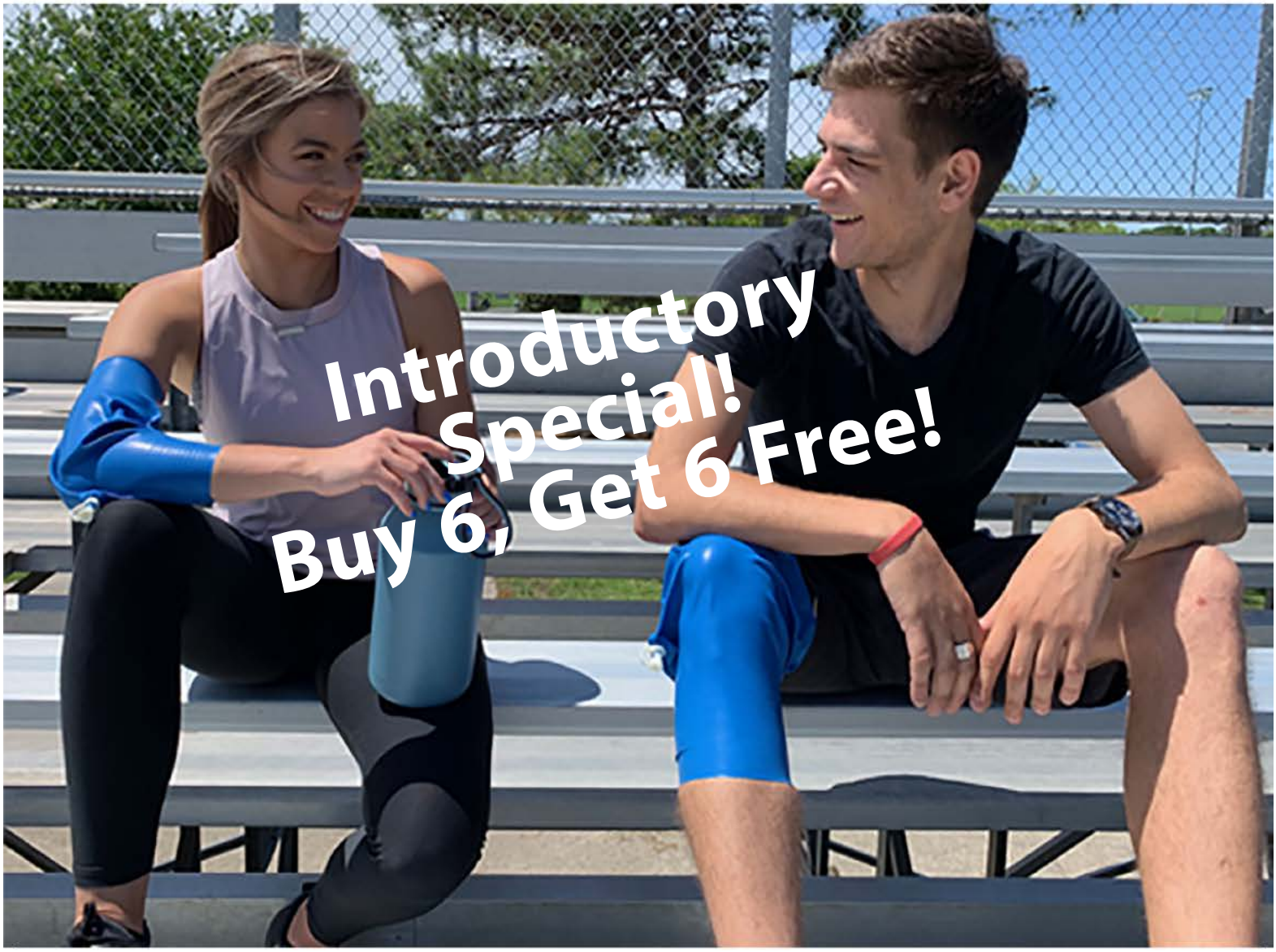

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INDUSTRY SNAPSHOT

Noteworthy products, association news, and market updates

COMFORT FOOTWEAR DESIGNED FOR STYLE AND FUNCTION

Inspired by fashion and designed for comfort, revere Shoes offers sandals, ballet flats, mary janes, loafers, and booties all with supportive, contoured footbeds that can be removed if required to fit custom orthotics. revere also offers fitting features such as extenders to lengthen straps for wide or swollen feet, fillers that can be inserted into shoes to customize fit, and options to reduce the length of straps for narrow-fitting feet, all without diminishing the stylish look of the footwear. Founded in Australia and designed in collaboration with leading podiatrists and pedorthists, revere's comfort footwear offers on-trend designs in soft, supple materials combined with function, fit, and support. Contact revere Shoes for more information or to discuss options to either dispense the company's footwear and sandals direct or become a referral partner.

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revereshoes.com

PT PROFESSOR AUTHORS NEW GUIDELINE TO TREAT PFP

University of Montana (UM) Assistant Professor Richard Willy, PT, PhD, is the lead author on a paper that offers new guidelines for treating patellofemoral pain (PFP), often known as runner's knee. PFP affects 25% of the general population every year, with women reporting PFP twice as often as men. Willy's paper finds that exercise therapy, namely hip and knee strengthening treatments prescribed by a physical therapist, is the best recovery approach for individuals with PFP.

"While it might be tempting to seek quick fixes for knee pain, there is no evidence that non-active treatments alone, such as electrical stimulation, lumbar manipulations, ultrasound or dry needling, help persons with PFP," he said. "Persons with PFP should seek clinicians who use exercise therapy for the treatment of this injury."

Willy (at left), is the lead author on a paper that offers new guidelines for treating runner's knee. Image courtesy of UM.

The recommendations were recently published as a Clinical Practice Guideline in the Journal of Orthopaedic & Sports Physical Therapy. The Clinical Practice Guideline aims to improve the quality and standardization of care provided to patients with knee pain while also providing reimbursement guidelines for insurance companies. Key takeaways from the Clinical Practice Guideline include:

- An exercise program that gradually increases activities such as running, exercise classes, sports or walking, is the best way to prevent PFP.
- Adolescent athletes who specialize in a single sport are at 28% greater risk of PFP than athletes who participate in a variety of sports.
- An important way to reduce the risk of PFP in military populations is maximizing leg strength, particularly the thigh muscles.
- Pain does not always mean there is damage to the knee.

To access the article, visit jospt.org/doi/full/10.2519/jospt.2019.0302#_i2.

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Ottobock's expertise in custom orthotic fabrication and carbon composites come together to produce an inspiring custom carbon fiber AFO (CCAFO). Crafted from carbon prepreg, this lightweight and low-profile ankle-foot orthosis (AFO) provides a solution for individuals with plantar flexion weakness and those needing triplanar support for the foot and ankle. The design stores and returns energy for propulsion while providing function of the soleus muscle and third rocker mechanics (heel off). This latest addition to the Ottobock line of AFOs is custom-made to match the patient's specific height, weight, and activity level. For more information, contact Ottobock's professional support staff via phone or the company's website.

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Inspired by the rough, dry, cracked feet of professional dancers and dance students, Love, Lori is dedicated to providing healthy foot care that soothes and repairs battered feet. Now available from Love, Lori is Foot Finish Foot Repair Cream. The antifungal cream is formulated with tea tree oil, rose oil, and lavender to fight foot infection and odor while reducing inflammation. It also includes the moisturizing properties of macadamia nut oil, canola oil, and olive oil. Other natural ingredients include eucalyptus oil, beeswax, geranium oil, vitamin E, and vitamin C. Recommended for daily use, this cream helps to fight such common foot ailments as athlete's foot, toenail fungus, foot odor, itching, and dry skin. This product has not been tested on animals.

Love, Lori
love-lori.com

NEW DME QIC CONTRACT EFFECTIVE SEPTEMBER 1

Effective September 1, the Durable Medical Equipment (DME) Qualified Independent Contractor (QIC) contract for administering all reconsiderations (second-level appeals) on processed DME claims has been transitioned to the contract awardee, MAXIMUS Federal Services. All reconsideration requests must now be submitted to Maximus Federal Services, Medicare DME, 3750 Monroe Avenue, Suite 777, Pittsford, NY 14534-1302. They can also be submitted via the QIC Appeals Portal at qicappeals.cms.gov.

The DME QIC workload includes new fee-for-service appeals for the US and US territories, telephone discussions, and reopening activities under the Telephone Discussion and Reopening Process Demonstration.

For more information on the second level of appeal, visit the Centers for Medicare & Medicaid Services website: cms.gov/Medicare/Appeals-and-Grievances/OrgMedFFSAppeals/ReconsiderationbyaQualifiedIndependentContractor.html.

RUNTIME BAROPODOMETRIC TREADMILL

The RunTime baropodometric treadmill analyzes posture accurately by calculating and showing the plantar pressures during walking and running. According to Sensor Medica, it was developed using the latest technologies, and in combination with freeStep software, RunTime belongs to the new generation of integrated instruments for postural evaluation and biomechanical analysis. Product highlights include: auto indexing of symmetries; resistive sensors and conductive rubber; sensors coated in 24K gold for repeatability and reliability of analyses; sampling frequency up to 200Hz in real time; USB interface; high performance in combination with freeStep software; footwork area is 120cm x 40cm; speed of up to 20km per hour; inclination from 0-12%; and maximum load of 130kg.

Sensor Medica
208/561-2286
sensormedicausa.com

5 ½" DOUBLE-ACTION PROFESSIONAL NAIL CUTTERS

New to the PediFix product line is the 5 ½" heavy-duty professional nail nippers, which are packaged for sale to appropriate patients for at-home care, yet are tough enough for clinical use. According to the company's president and CEO, Christopher Case, the new nail clippers were inspired by requests from patients longing for at-home devices capable of trimming thick and fungal nails like those used by physicians. The nail cutters are made from stainless steel. They feature ¾", surgical-quality blades—curved or straight; etched handles for easy gripping, a barrel spring, and latched safety closing mechanism. They can even be used by those with hand weakness. Contact PediFix to order, get additional information, or request a free sample.

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HIGH ACHILLES ANKLE BRACE RELIEVES PAIN

The High Achilles Ankle Brace was designed to relieve pain in the back of the heel caused by inflammation of the Achilles tendon; it is appropriate for post-Achilles tendon rupture, tendonitis, and strains. According to BRD Sport, the 3D knit technology creates targeted intermittent compression and reduces swelling while relieving pain and enhancing circulation. This brace features a viscoelastic insert that runs along both sides of the Achilles tendon. The extra length of the viscoelastic insert helps to gently massage and stimulate the tissues in the affected area to relieve pressure from above the heel, while the extra length of the brace supports the upper muscles and tendons. A Velcro tab opening in the front allows for easy donning. The Achilles Ankle Brace is constructed from a breathable, washable material. It can be used for either foot, and is available in sizes XS-XXL.

BRD Sport
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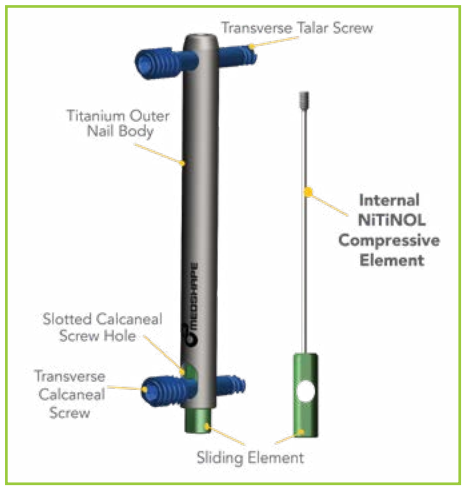
POLICY ARTICLE REVISED FOR THERAPEUTIC SHOES

The Durable Medical Equipment (DME) Medicare Administrative Contractor (MAC) Policy Article (PA) for Therapeutic Shoes for Persons with Diabetes was recently revised, as follows. The effective date is January 1, 2019:

- Added: Healthcare Common Procedure Coding System A5514 (Mult den insert dir carv/cam) to the reference of "inserts" for which impressions, casts, or CAD-CAM images, of the beneficiary's feet, are to be obtained by the supplier at the time of item selection.

This information is only a summary of revisions; complete information can be found by reviewing the Local Coverage Determination and PA.

MEDSHAPE LAUNCHES DYNANAIL MINI FUSION SYSTEM



MedShape, Atlanta, GA, an orthopedic device manufacturer, announced the launch of its DynaNail Mini™ Fusion System, which is available in 7mm and 8mm diameters and 60mm to 100mm lengths. Featuring MedShape's patented superelastic nickel titanium (NiTiNOL) technology, the DynaNail Mini is the first orthopedic device designed specifically for subtalar fusion that offers maintained active compression post-surgery to promote healing and joint stability, according to the company. NiTiNOL and its pseudoelastic properties have been shown to be advantageous in applications where dynamic compression is required to facilitate healing of a fusion site. The double transverse screw design ensures solid fixation, with no migration or loosening.

During surgery, a NiTiNOL Compressive Element is held in the stretched activated position and fixated with transverse screws in the talus and calcaneus. Post-surgery, the Compressive Element will automatically recover its stretched length in response to bone resorption or settling, allowing for compression to be maintained throughout the healing process. Manual compression can also be applied during surgery using the Mini Targeting Frame ensuring tight bone apposition immediately post-surgery. The frame also features a robust, universal one-arm design that allows for reliable drilling and screw placement. The DynaNail Mini comes packaged with the Compressive Element pre-stretched on a disposable Nail Guide that is attached to the Targeting Frame, thereby reducing the number of steps in the operating room.

OTC LUX STEP INSOLE

Cluffy has introduced the Lux Step insole. This office-dispensed, over-the-counter (OTC) product is designed for optimization of first ray function and to address elements needed for effective relief of plantar fasciitis. A patent-pending dynamic arch design allows for optimum arch support. The insole incorporates

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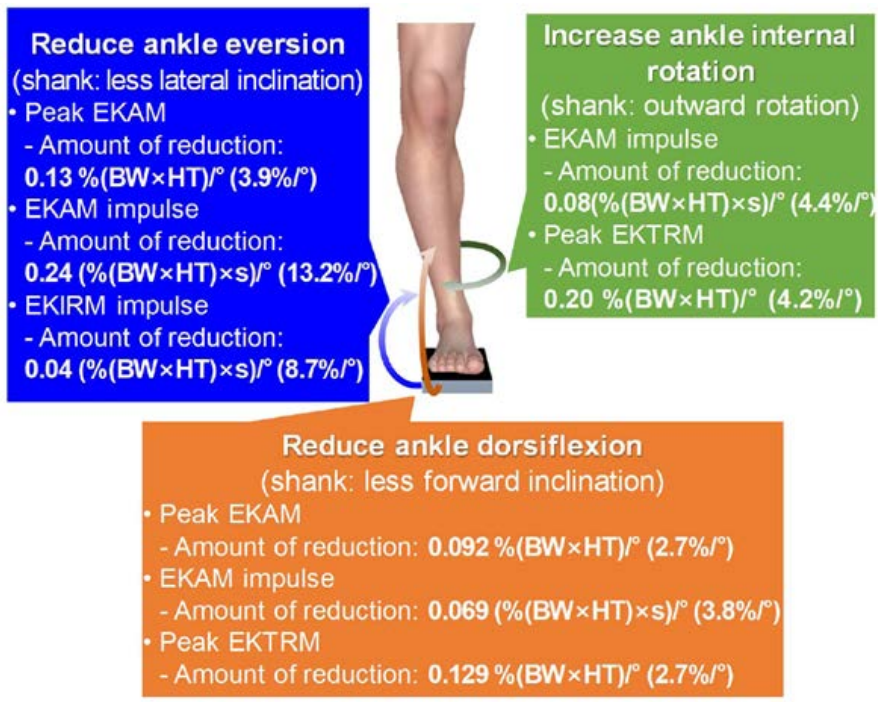
JMS Plastics Supply
800/342-2602
jmsplastics.com

STUDY PRESENTS REAL-TIME BIODYNAMIC KNEE OA EVALUATION SYSTEM

A research team affiliated with Ulsan National Institute of Science and Technology (UNIST), Republic of Korea, has designed a system that can quantitatively complement the diagnosis of knee arthritis, which is traditionally performed based on x-rays and a physician's exam. The system is less expensive to use than a motion analysis room, and data collection and analysis can be performed in real time. This work has been led by Sang Hoon Kang, PhD, a professor in the UNIST School of Mechanical Aerospace and Nuclear Engineering, in collaboration with researchers from Korea Institute of Science and Technology (KIST), University of Maryland, and Weill Cornell Medical College at Cornell University. The findings were published in the June 2019 issue of *IEEE Transactions on Neural Systems and Rehabilitation Engineering.*

The team developed a system to diagnose knee arthritis while walking. The system uses a modified elliptical trainer and an inexpensive, compact, 6-degree of freedom goniometer. By measuring the force on the foot of the exercise equipment and the ankle movement while the patient is walking, all the forces on the knee joint can be calculated in real time to determine the severity of arthritis. Since the force applied to the joint and the rotation of the adduction rotation can be identified in real time, the patient can also receive real-time gait retraining strategies/guides.

"This technology can provide diagnostic assistance and advanced biofeedback rehabilitation training through the provision of objective data for patients with knee arthritis," said Kang.



An image showing results of the Knee OA assessment using the modified elliptical and goniometer system Kang and his colleagues designed. Image courtesy of UNIST.

How Well Did You Read This Issue?

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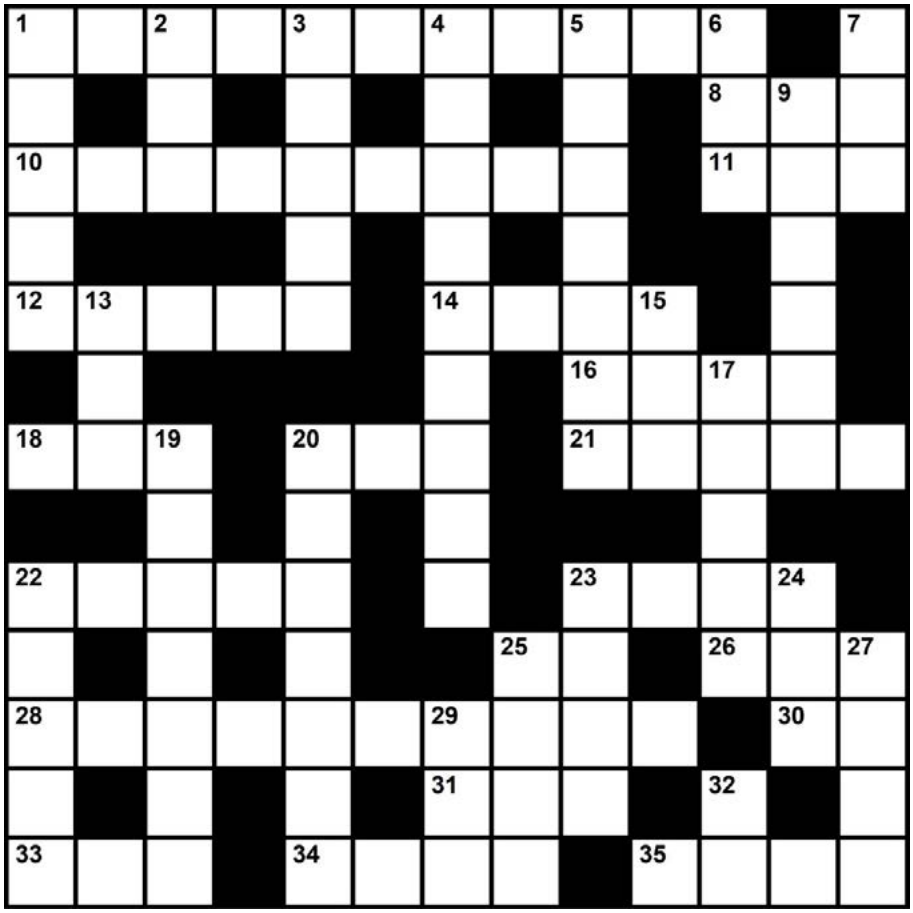

ACROSS

1 Hosiery to control varicosities; goes with 4 down
8 Miner's load
10 The "S" in GSV
11 "I read it in ___ Spiegel"
12 Undersides of feet
14 Go-___ (racing vehicle)
16 Muscle that supports the arm, short for
18 Pouch-like structure
20 Used in healing broken bones
21 Fibrous connective tissue
22 Bone of the lower leg
23 Fleshy part of the leg
25 Designates an osteopathic physician
26 Right-angle bend in a pipe
28 Reflected waves yield diagnostic images
30 Branch of computer science with some medical applications, abbr.
31 "Follow the _____": GPS offering, abbr.
33 Suffers from
34 Passes through soft tissue but not bone
35 System for chronic venous disorders, abbr.

DOWN

1 Immobilize a joint while bone heals
2 Navigation aid
3 Swamp plants
4 See 1 across
5 Used to reduce pain in the feet
6 Consent silently
7 ___ os, meds by mouth
9 Put a new bandage on
13 Eggs, biologically
15 ___geminal neuralgia
17 Site for the cuboid and navicular
19 Arm joint
20 Toe bone
22 Laying on hands as treatment
23 Photoreceptor cell of the retina
24 Sunshine state, abbr.
25 Tax
27 Gait caused by an injured leg
29 "Doctor, is it a boy ____ girl?" (2 words)
32 How a child's balloon rises, symbol

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