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LOWER EXTREMITY REVIEW

September 16 / volume 8 / number 9

Clinician-Patient Communication:

How personal connections can improve outcomes

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FUNCTION ANALYSIS
CHRONIC ANKLE INSTABILITY, GAIT, AND MUSCLE ACTIVITY

PAIN MANAGEMENT
SUPPORT FOR DRY NEEDLING BUILDS AMONG CLINICIANS

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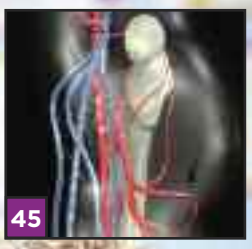

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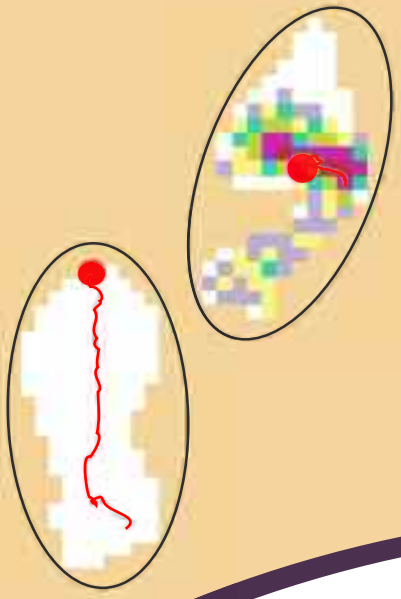

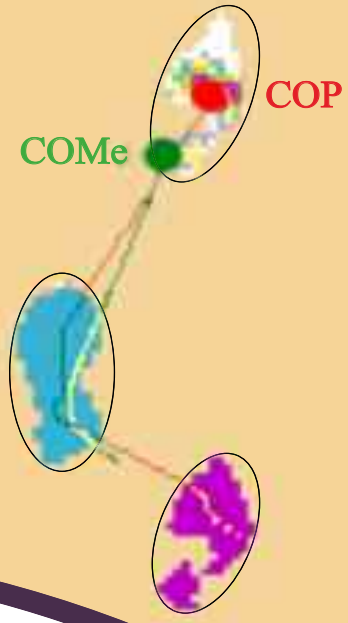

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out on a limb: Brains, sprains, & the NFL

National Football League (NFL) players say they worry more about lower extremity injuries than concussions. But a growing body of evidence suggests the latter injury actually increases the likelihood of the former.

In a 2014 USA Today survey, 293 NFL players were asked which body part they were most concerned about injuring in a game. Nearly half (46%) specified the knee or other aspects of the legs, while just 24% picked head and neck injuries.

Given the relatively brief careers of professional football players and the fact that their contracts are not guaranteed, it makes sense they would worry most about the injuries they think will result in the most time away from competition.

"Why would I want to sit there for eight months and not do anything, when with a concussion I'll just wake up and I'll be ready to go again," New England Patriots tight end Rob Gronkowski, who tore his anterior cruciate ligament in 2014, said in an April 2015 Bleacher Report interview.

It's true that—even with the league's new concussion management protocol in place—players rarely miss more than a game or two after a concussion, whereas an anterior cruciate ligament (ACL) or Achilles injury can wipe out a player's entire season. But Gronk and other players might be more concerned about head injuries if they knew that sustaining a concussion significantly increases the risk of one of those lower extremity injuries they fear more.

In mid-August, researchers from the University of Florida in Gainesville published a study in *Sports Medicine* that followed 73 Division I college athletes who returned from a concussion with at least 30 days remaining in their season. Compared with matched control athletes who had not had a concussion in a year, the concussed athletes were 3.39 times more likely to sustain a lower extremity injury during the same season.

Two weeks later, researchers from the University of Delaware in Newark reported significant associations between a history of concussion and a history of lower extremity injury, based on a survey of 335 student athletes. In that study, athletes with a history of concussion were 1.69 times more likely to report a history of lower extremity injury.

These are only the most recent studies to suggest such brain-sprain associations (see "Risk of lower extremity injury increases after athletes return from concussion," February 2016, page 13). It's still unclear which specific aspects of concussion contribute to the increased risk of lower extremity injuries, or the extent to which the timing of an athlete's return to sports after a concussion might affect that risk. But the body of evidence is becoming difficult to ignore.

> Players might take concussion prevention more seriously if they knew it could also help prevent season-ending leg injuries.

It's understandable that ACL tears and other lower extremity injuries are what NFL players fear most. It's even somewhat understandable that they are more concerned with the short-term implications of a concussion than the long-term consequences. But, knowing that preventing a head injury can help prevent season-ending leg injuries as well as long-term neurological complications, even Gronk might take concussions a little more seriously.

Jordana Bieze Foster, *Editor*

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Offloading and obesity

Gait study data have OA implications

By Katie Bell

Gait interventions can alter knee loading in obese patients, which may have implications for knee osteoarthritis (OA), according to three studies presented in August at the annual meeting of the American Society of Biomechanics in Raleigh, NC.

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Offloading the knee during gait in obese patients can be challenging, said Joaquin A. Barrios, DPT, PhD, an associate professor in the Department of Physical Therapy at the University of Dayton in Ohio.

"Obese patients, from a clinical biomechanics perspective, often converge on movement patterns during gait that are abnormal due partly to movement restrictions," Barrios said. "As one example, greater thigh girth may impede the thighs from passing each other freely during midstance, so proximal kinematics will organically change to allow for this clearance."

Barrios and colleagues evaluated the effects at the medial tibiofemoral joint of both increasing and decreasing walking speed by 10% in 14 healthy participants while ambulating overground with and without a simulated 10% weight gain.

Simulated weight gain increased all loading parameters, including peak force, loading rate, impulse per step, and impulse per kilometer. Meanwhile, a faster gait speed increased the peak amplitude of the joint loads but decreased impulse per step and per kilometer due to reduced exposure time and fewer loading cycles.

Continued on page 14

Even mild LLD affects gait in ways that could speed knee degeneration

The effects of mild limb-length discrepancy (LLD) on gait in patients with knee osteoarthritis (OA) may contribute to disease progression, according to research epublished in August by *Clinical Biomechanics*.

In 15 patients with unilateral knee OA, researchers from Queens University in Kingston, Ontario, Canada, and the Federal University of Minas Gerais in Belo Horizonte, Brazil, assessed the effects of wearing sandals with sole thicknesses that differed by 1.45 cm, compared with wearing two sandals of the same sole thickness. For the LLD condition, the thinner-soled sandal was worn on the affected limb.

Compared with the control condition, the LLD condition was associated with altered rearfoot, knee, hip, pelvic, and trunk kinematics and ankle, knee, and hip kinetics.

Of note, the LLD condition was associated with greater knee extension moment during loading response and knee flexion moment during terminal stance than the control condition. These increases in sagittal plane loading associated with even mild leg-length discrepancies could contribute to accelerated knee OA progression, the authors hypothesized. ler

–Jordana Bieze Foster

Source:
Resende RA, Kirkwood RN, Deluzio KJ, et al. Mild leg length discrepancy affects lower limbs, pelvis and trunk biomechanics of individuals with knee osteoarthritis during gait. Clin Biomech 2016 Aug 3. [Epub ahead of print]

Not all meniscal pathology on MRI is relevant in patients with knee OA

Some—but not all—characteristics of meniscal damage on magnetic resonance imaging (MRI) scans are associated with knee osteoarthritis (OA) severity and two-year progression, according to research from Tufts Medical Center in Boston, MA.

As an ancillary project to the Osteoarthritis Initiative, investigators analyzed MRI scans of 465 patients with knee OA (71% had a Kellgren-Lawrence radiographic severity grade of 2 or higher) at two visits, two years apart. Findings were adjusted for patients' age, sex, and body mass index.

Meniscal maceration was significantly associated with baseline knee pain, prevalence of end-stage knee OA, and bone marrow lesion (BML) volume, along with the change in BML volume at two years.

Morphological deformity/extrusion (altered meniscal shape and/or extrusion but no apparent substance loss) was also significantly associated with baseline BML volume and change in BML volume at two years.

Neither intrameniscal signal nor the presence of meniscal tear were associated with any of the assessed measures of knee OA severity or progression. *Osteoarthritis & Cartilage* epublished the findings on August 15. ler

–Jordana Bieze Foster

Source:
Antony B, Driban JB, Price LL, et al. The relationship between meniscal pathology and osteoarthritis depends on the type of meniscal damage visible on magnetic resonance images: data from the Osteoarthritis Initiative. Osteoarthritis Cartilage 2016 Aug 15. [Epub ahead of print]

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"Offloading interventions should complement interventions aimed at pain and inflammation reduction, strengthening, diet, and exercise patterns, among others," Barrios said.

A separate study also looked at velocity, specifically which combinations of walking velocity and stride length could help reduce peak knee internal extension and abduction moments in 10 obese participants. They found that decreasing velocity at the participants' preferred or decreased stride length was the most effective combination for reducing both frontal and sagittal plane moments.

Study author Michael Bijman, MSc, a doctoral student in the Department of Physical Therapy & Rehabilitation Sciences at Drexel University in Philadelphia, noted that altering velocity and stride length would be easier for most patients than gait modifications focused on the frontal plane.

"Patient acceptance was definitely considered when designing the interventions," Bijman said.

He hypothesized that similar effects would occur in obese patients with knee OA.

"I can only speculate, but I think similar results will be seen," Bijman said. "A decrease in speed with a preferred or decreased stride length will result in the same findings as we presented."

A third study, which was concurrently published in the July issue of *Gait & Posture*, examined the influence of obesity on the incidence of heel-strike transient, a rapid transient rise in the vertical ground reaction force (GRF) after heel strike that is indicative of a high rate of loading, which can contribute to knee OA.

The study included 30 participants, half of whom were obese and half of normal weight. When walking at a standardized speed, 53% of the obese participants demonstrated a heel-strike transient, compared with just 20% of the normal-weight participants.

The study did not look at interventions to modify heel strike transient, but addressing arthrogenic muscle inhibition—which is common in individuals with knee pathologies—may help, according to lead author Derek Pamukoff, PhD, an assistant professor in the Department of Kinesiology at California State University, Fullerton.

"Improving quadriceps function by removing inhibition may be a suitable strategy for attenuating ground reaction force during walking," Pamukoff said.

The authors suggest further study to examine factors that may affect the incidence of heel-strike transient, such as quadriceps function and walking speed, and to evaluate the influence of heel-strike transient on knee OA development.

Sources:

Barrios JA, Wilson JD, DiLiberto FE, et al. Effects of altered walking speed and simulated weight gain on medial tibiofemoral joint contact force parameters. Presented at 40th Annual Meeting of the American Society of Biomechanics, Raleigh, NC, August 2016.

Bijman MP, Milner CE. The influence of walking velocity and stride length on the knee in obese adults. Presented at 40th Annual Meeting of the American Society of Biomechanics, Raleigh, NC, August 2016.

Pamukoff DN, Dudley RI, Vakula MN, Blackburn JT. Greater incidence of heel strike transient in obese compared to normal weight adults. Gait Posture 2016;49:181-183.

Clinician-patient communication:

How personal connections can improve outcomes

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Increasingly, lower extremity practitioners are realizing the clinical importance of patient communication. They're also starting to realize that effective communication requires more than just using the right words.

By Hank Black

The clinician with the "doctor knows best" attitude, the one with the indecipherable medical jargon, the "cold fish" who cannot look patients in the eye and erects an invisible barrier to questions or opinions. They are among the practitioners whose inability to communicate adequately with patients can lead to low satisfaction scores, loss of patients to competitors, and, most important, poor clinical outcomes. That's why, increasingly, lower extremity practitioners are exploring ways to improve their patient communication skills.

The recognition of the critical importance of provider-patient communication took flight with the emergence in recent decades of patient-centered concepts of care, and is given added weight by the incorporation of patient satisfaction scores in determining compensation from Medicare and other payers.

A patient-centered relationship requires that the patient be involved throughout the treatment process[1] via a structured model of interaction that includes an explanation of the disorder, treatment goals, and clinical evidence, all delivered by the practitioner in non-emotional terms and without medical jargon.[2,3] The provider must apply clinical skills with genuine personal engagement in addition to using the right words.[4]

"A patient is, first, a person, and I want to engage with them just how I would with any person," said Grace Torres-Hodges, DPM, who is in private practice in Pensacola, FL. "I always try to remember that as a healthcare professional in a world of computers, automation, and regulation, good communication technique is something I can control in order to gain the trust of my patient. If we forget to remember that the foot with the diabetic ulcer or that ankle sprain is connected to a person, we neglect the most important part of the entire visit—establishing the relationship between the doctor and the patient."

Evidence continues to accumulate suggesting that patient-centered communication has a positive impact on patient satisfaction, treatment adherence, and self-management of diabetes and other chronic diseases.[5-8] Clinicians for whom that's not incentive enough might also consider that breakdowns in communication make it more likely that patients will initiate malpractice actions.[9]

Improved communication can be begin with small gestures, sometimes nonverbal. Torres-Hodges starts with a knock on the exam room door, a self-introduction, and a moment of touch by shaking hands.

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"You have to earn their trust through honesty," she said. "Eye contact is important, then listen and observe. Hear how they are talking, acknowledge their words with a nod. Don't be afraid to smile, and when you talk, speak slowly and expect the same from your staff. It takes consistency for it to become a habit, but almost anyone can do it."

Positivity is a plus for achieving a bond with patients. Morin et al showed a positive style of communication helped decrease early clubfoot recurrence.[10] And a study of patients with knee osteoarthritis (OA) found patients whose provider communicated a high expectation of reduced pain following acupuncture or sham acupuncture had less pain than patients whose provider was neutral about pain relief.[11] A secondary analysis concluded the provider's style of communication heightened the benefit of treatment, mediated by patient self-efficacy. [12]

By the same token, negative emotional language should be avoided, according to researcher Jaap J. van Netten, PhD, who has examined how poor communication can discourage patients from

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wearing prescribed orthopedic footwear.[13] Persons with rheumatoid arthritis, for example, may feel guilt or shame if you refer to their foot as being "difficult," said van Netten, a senior research fellow at Queensland University of Technology's School of Clinical Sciences in Brisbane, Australia.

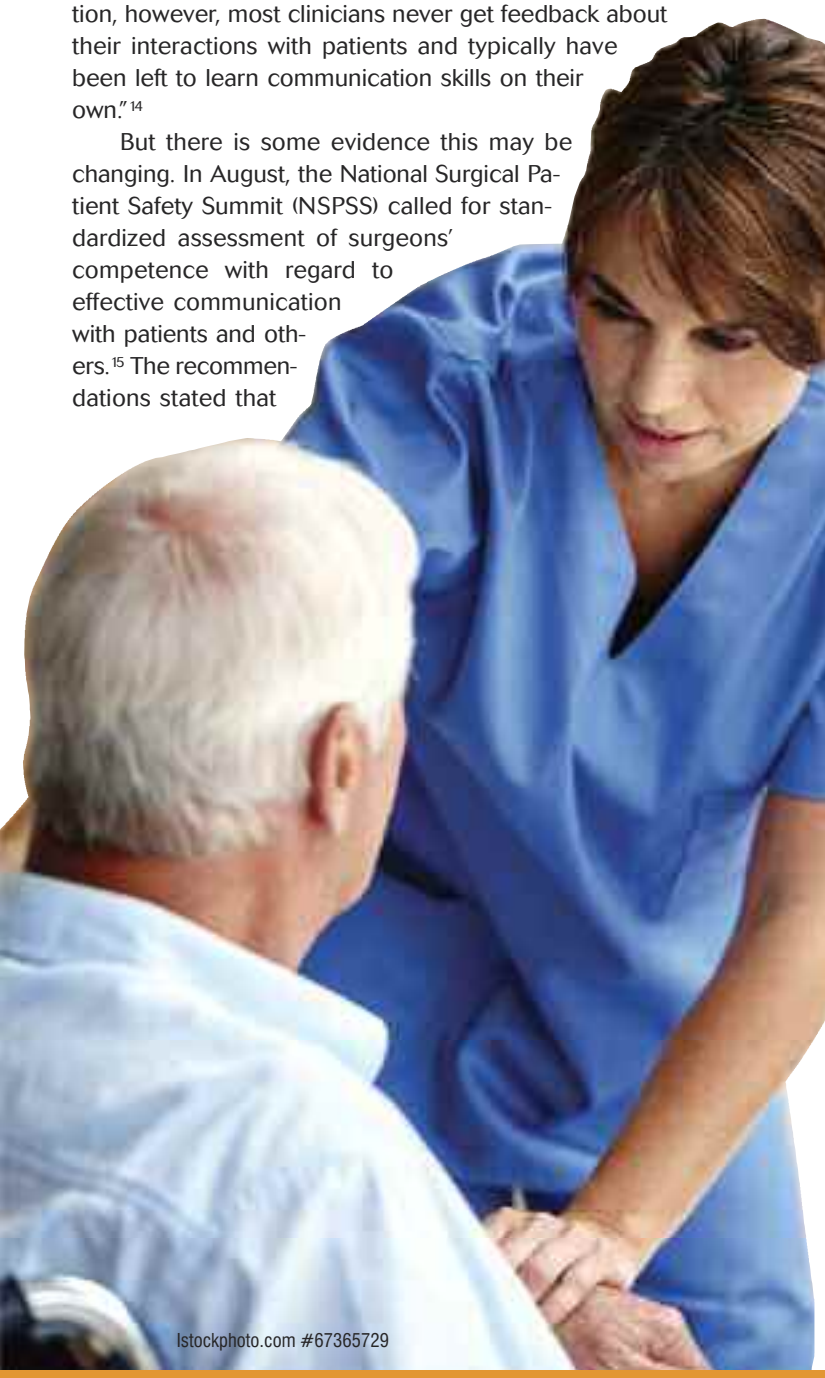
"Negative communication can destroy a relationship and diminish the chance for the client to have a role in the process," he said.

Despite recognition of their importance, there's still little inclusion of communication skills in educational curricula for healthcare professionals.

"There are a limited number of education hours and everybody is competing for them," according to Michael D. VanPelt, DPM, FACFAS, assistant professor of surgery at the University of Texas Southwestern Medical Center in Dallas.

Despite the acknowledged importance of good communication, however, most clinicians never get feedback about their interactions with patients and typically have been left to learn communication skills on their own."[14]

But there is some evidence this may be changing. In August, the National Surgical Patient Safety Summit (NSPSS) called for standardized assessment of surgeons' competence with regard to effective communication with patients and others.[15] The recommendations stated that nontechnical skills such as patient communication, including patient-centered shared decision-making, are necessary for optimal patient safety in the perioperative period.



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The American Academy of Orthopaedic Surgeons and the American College of Surgeons sponsored the summit, and its recommendations will be used to create National Surgical Patient Safety Standards and surgical safety education curriculum proposals.

The event emphasized the need for undergraduate medical education to include the teaching of communication skills that would be reinforced in residency programs with simulation training and appropriate feedback, and additionally backed by continuing education throughout a clinician's career. It also recommended that knowledge of the shared decision-making process be a requirement for surgical residency programs and surgeon credentialing.

Skills for residents

With funding from the Hartford Foundation, the Hospital for Special Surgery (HSS) in New York City started a program in 2009 designed to improve the communication skills of orthopedic surgery residents when relating to older adults.

"By 2030, twenty percent of the US population will be over sixty-five years old, so it is vital for physicians to develop effective and sensitive communication skills during their residency training to promote positive outcomes with older adults who often perceive themselves as stigmatized and powerless in healthcare settings," said program director Linda Roberts, LCSW.

The program is structured so small groups of third-year residents, with the guidance of a social worker who specializes in aging issues, are made conscious of the needs of older adults as well as long-standing myths about this population. Many young doctors think all older patients are cranky and can't or won't learn anything new, Roberts said. In the sessions, residents are taught effective communication skills to use with those patients, including eye contact, the use of open-ended questions, and asking patients to repeat back what they heard the doctor say.

In the program's second phase, the residents present a musculoskeletal topic to about 25 adults aged 65 years and older. Following the presentation, they interact more personally with a smaller group of seniors by demonstrating exercises.

"We observe the sessions and give feedback," Roberts said. "The idea is to sensitize residents to the needs of older adults and to teach ways to gain the trust of the patient so they can form a partnership that allows for shared decision-making and management of patient expectations."

From 2009 to 2015 64 residents went through the program. Surveys administered before and after training showed a significant increase in residents' mean knowledge of aging and older people and in their attitude toward older adults, well as a decrease in their anxiety level when talking with older adults.

Charles Cornell, MD, professor and clinical director of the Department of Orthopedic Surgery at HSS, founded the program. Cornell sees communicating better with older adults as critical to the future of his specialty as the US population ages.

"Communication has been overlooked as a necessary skill in

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orthopedic postgraduate education," Cornell said. "I have practiced alongside geriatricians who said conversations with elderly patients are often not straightforward. They may interpret what you say differently than what you intended. The word 'stiffness,' for example: To me, stiffness of the knee is a direct measure of how much the joint moves, but to the patient, it means an uncomfortable feeling."

For the residents, the program is an exercise in self-awareness of their communication abilities, giving them a basis from which to assess their skills going forward, he said.

"Interviewing the patient is one of our most basic tools, and if the patient is not following what the doctor is saying, those tools are not being used correctly," Cornell said.

Empathy in providers

Clinician empathy and emotional management ability have been linked to higher patient satisfaction scores.[16] Studies have suggested practitioners' ability to manage their own and others' emotions can help improve empathy, relationships with patients, and teamwork and communication skills.[17]

If providers are short on empathy, some suggest, they might at least turn to professionalism to benefit their relationships with patients and boost patient satisfaction scores. A widely quoted 2008 article from *The New England Journal of Medicine*[18] called for increased medical school and postgraduate training in "etiquette-based medicine" that would at least result in a respectful and attentive practitioner, if not a compassionate one. The author suggested using a checklist for clinician etiquette would systematically teach good manners and emphasize not how providers feel, but only how they behave.

For a health professional visiting a hospitalized patient, for example, the six items on the checklist are:

- Ask permission to enter the patient's room;
- Introduce yourself;
- Shake hands;
- Sit down;
- Explain your role on the team; and
- Ask how the patient is feeling about being in the hospital.

Two 2013 observational studies of how often interns and hospitalists completed the checklist showed the practice had not caught on: In almost a third of 1000 patient encounters, the doctors failed to do a single one of them.[19,20] It may be no wonder, then, that fewer than 25% of hospital patients can name their doctor.[21]

Beyond core skills

van Netten, lead author of a recent clinical note on the topic, said, "Communication techniques for improved acceptance and adherence with therapeutic footwear.[13] A shoe or brace may be 'perfectly' built or modified, but it is only effective if worn. As such, patients have an increased role in their own care, and patient perspective must be sought by the clinician."

When patients believe their provider hasn't understood them properly, they're less likely to adhere to the footwear or device as necessary, he said.

"Orthotists and prosthetists might master the core skills necessary to produce therapeutic footwear, but we also need to learn techniques of communication," van Netten said.

His group described two techniques for improving communication, person-centered communication, and shared decision-making.

"It's most important," he said, "to elicit the patient's attitudes about their condition, and that requires making a personal connection by building a relationship in which they feel you are listening to them and understanding what they say. It's important, for example, to repeat back to the patient a summary of what you hear them saying, and for the patient to relate back to you what they are hearing you say."

Shared decision-making as part of the structured consultation, he said, means the practitioner and the patient are working together toward the best choices available for care by jointly negotiating and agreeing on treatment plans.

"In providing therapeutic footwear," van Netten said, "the process should not proceed until the patient confirms that they are actively choosing the footwear, rather than passively accepting it but likely not wearing it."

Clear language is also a helpful element in communicating with a patient. In one study describing a patient who was receiving

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prescribed footwear, the patient showed confusion and said, "The doctor seriously just kept talking, saying it is to protect your feet. I was left wondering, to protect them from what?"[22]

van Netten said, "This illustrates inaccurate assumptions and poor communication, both of which put the patient's health at risk."

Practitioners may use simple visual aids to help with communication.

"For example, to describe the fact that fifteen percent of people with diabetes will experience a foot ulcer, you could show a picture of one hundred people, with fifteen of them colored differently," he said.

Communication tool kit

Communication aids can also improve practitioner-patient discussions on healthy footwear, as Farndon et al described earlier this year.[23] The British group developed an online tool kit to assist in identifying and addressing barriers to patient acceptance of suitable footwear.

Torres-Hodges frequently uses visual communication aids in her practice to help explain a pathology and a treatment plan.

"I have handouts to augment the clinical conversation," she said. "For instance, if a patient doesn't understand what a bunion is, I have charts to illustrate that, or I draw it myself. It also helps with understanding if I explain concepts such as a biomechanical concept like pronation, by comparing it to something the patient is more familiar with, such as an alignment problem with their car, that if continued will lead to serious problems down the road."

That analogy may help an adult understand the condition, but a pediatric patient may relate better with an example from a popular TV show or video game, Torres-Hodges said.

"That puts it on their level—though admittedly, teens and tweens are sometimes the hardest to develop a relationship with," she said. "With them, I always start the conversation in the room with them first, then introduce myself to their parent."

If a patient doesn't seem to completely understand an explanation, Torres-Hodges asks if there is an accompanying relative or friend who can serve as a second set of ears. Alternatively, she emails important information to the patient and caregiver.

"It's so important that the patient understands and participates in the decisions," she said. "You're getting them involved in their own healthcare. It's our responsibility to advise and guide them—to make sure someone with plantar fasciitis, for example, understands that it's necessary to stretch before taking the first step from bed in the morning, wear supportive shoes, and take their anti-inflammatory medication. If I'm not conveying the message understandably, I haven't done my job. We have to engage, bond, and maintain open a line of communication with those who entrust us with their care."

Perception counts

Patient-centered communication has been associated with closer adherence to treatment recommendations and improved health status and patient and provider satisfaction.[24-27] However, research suggests that outcomes from a clinic visit may be affected more by the patients' perception of the quality of the encounter than by the providers' visible behaviors.[28-30]

A recent study conducted at Baylor College of Medicine in Houston, TX, found patients' perception of the quality of providers' communication quality is influenced by sociodemographic and health-related characteristics, including patients' healthcare access, age, race, and education.[31] For this study, the researchers analyzed data from the Health Information National Trends Survey (HINTS), a nationally representative survey administered by the National Cancer Institute. HINTS asks patients how often their health professional gave them the opportunity to ask questions, addressed the patient's feelings, involved them in decisions, gave clear explanations, allowed sufficient time, helped with uncertainty, and made sure the patient understood the next steps.[32]

Based on their analysis of almost 8500 respondents from the 2011-2013 iterations of HINTS, the results indicated most people in the US have positive perceptions of the quality of their providers' communication. Respondents aged 65 years and older, those who had had cancer, retirees, homemakers, students, and those in excellent/very good health tended to rate the quality of their providers' communication positively; those who were unemployed, in fair/poor health, and who didn't have a regular healthcare provider or health insurance gave their providers' communication lower ratings.

Also interesting were the findings that respondents with at least a college degree were more likely to rate the quality of their provider's communication as poor, compared with those who had less than a high school education. Unexpectedly, they found non-Hispanic black respondents were more likely to report that their providers always allowed time for questions and made sure that they understood what would happen next.

"Our study yields very important results about associated characteristics of perceptions and of communication between patients and providers," said Kiara K. Spooner, DrPH, MPH, CHES, the study's lead author and a research fellow in the college's Department of Family and Community Medicine. "However, we did not have data on patients' rationale for their perceptions. We hope to one day extend our research on patient-provider communication by qualitatively examining it from the perspective of both the providers and patients. This may help us gain a better understanding of patient-provider communication, as well as how it can be improved to achieve a higher quality of care."

VanPelt, the Dallas-based foot and ankle surgeon, sees a lot of barriers to good communication, including growing diversity among patients with regard to language and culture, an increase in the number of advanced professionals involved in patients' care, use of computers while interviewing, and the pressures for efficiency that leave less time for each clinician-patient encounter.

"But it's the job of the doctor to educate the patient and build a trust that will lead to a partnership that can develop and follow a treatment plan," VanPelt said. "Gaining that trust through shared decision-making or other techniques is vital. Patients are more interested today in researching their own condition, and encouraging that allows the patient to participate more fully in the conversation." ler

Hank Black is a freelance writer in Birmingham, AL.

References are available at lermagazine.com.

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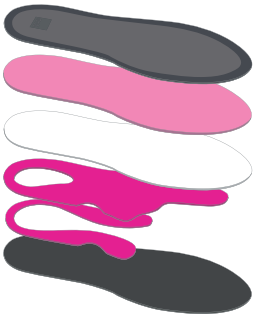

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Management of athletes with early-stage PTTD

By Frank Layman, PT, DPT, EdD, MT; and April Wilson, PTA, BS, CI, CKTP, IASTM

Posterior tibial tendon dysfunction (PTTD), known also as tibialis posterior tendon dysfunction, is one of the leading causes of acquired flatfoot in adults, but the abnormal biomechanics associated with PTTD are often overlooked by clinicians in the condition's early stages. The posterior tibial tendon is a major contributor to the structure of the medial longitudinal arch (MLA). The most frequent types of athletes we see with early PTTD are, in order of prevalence, runners, volleyball players, and tennis players. The increasing prevalence of clinic visits for this condition is associated with the continued growing popularity of running and other sports among participants of a range of ages.

PTTD's precise etiology is not known, but present theories implicate poor vascularization, abnormal foot mechanics (eg, exaggerated antagonist contraction of the peroneus brevis), or biomechanical changes.[1]

Over time, posterior tibial tendinopathies can lead to PTTD, and symptomatic tendon tears are one of the most important causes of pain and joint dysfunction; if the progression is allowed to go uncorrected, vascularization can be negatively affected. Among the intrinsic causes of PTTD, vascularization recently has been recognized as playing a major role.[1] In general, tendon blood flow decreases with increasing age and mechanical load. A decrease in vascularization can increase the probability of tissue damage as it decreases tissue flexibility and responsiveness. Another consideration is that the oxygen consumption of ligaments and tendons is 7.5% lower than skeletal muscles, which can contribute to slower healing rates.[2,3]

Because vascularization and oxygen consumption issues are associated with PTTD, we advocate early intervention in our practice. An evidence-based multimodal approach with an emphasis on good screening and early intervention has enhanced outcomes in our athletes.

The tibialis posterior muscle, the most deeply seated of the muscles associated with PTTD, originates on the inner posterior borders of the tibia and fibula. The tendon of the tibialis posterior muscle descends posterior to the medial malleolus and terminates by dividing into plantar, main, and recurrent components. The plantar portion inserts into the bases of the second, third, and fourth metatarsals and the first and second cuneiform. The recurrent portion inserts into the sustentaculum tali of the calcaneus. The main portion inserts into the navicular tuberosity. The tibialis posterior also contracts to control inversion and eversion and assist with ankle plantar flexion.

The pain and dysfunction associated with PTTD are related to changes in the biomechanics of the foot and ankle.[3,4] The posterior tibial tendon is needed to create biomechanical balance and help sustain a more neutral foot posture. Dysfunction of the tibialis posterior can lead to flat feet and valgus deformity in the rearfoot, associated with unopposed forces.

Early stages of PTTD

The onset of PTTD may be slow and progressive or abrupt. An abrupt onset is typically linked with a trauma, whether it be simple (a misstep) or severe (falling from a substantial height or an automobile accident).[5] PTTD is seldom seen in children, and increases in frequency with age.

PTTD is typically described as having four stages. This discussion will focus on the early stages, which progress relatively slowly. In stage I, the tendon is inflamed but intact; no deformity is evident. In stage II, the tendon is dysfunctional, and patients are commonly unable to perform a heel rise; acquired pes planus is evident, but this is passively correctable.

As mentioned, the functions of a healthy posterior tibial tendon are plantar flexion of the ankle, inversion of the foot and elevating the MLA. Elevation of the MLA locks the midtarsal bones, so the midfoot and hindfoot are stiff. All of this allows the gastrocnemius muscle to act more efficiently during gait. When the tendon is not healthy, the surrounding joint capsules and ligaments become weak. There is an eversion of the subtalar joint, abduction of the talonavicular joint, and valgus of the heel. In addition, the gastrocnemius can't function properly because of the change in its angle of pull, which affects gait and balance.[3,4,6] This can mean the other muscles used in the gait cycle will be overtaxed in patients with PTTD.

Examination

It's important to examine the whole lower body and not just the foot, as knee valgus can accentuate the appearance of pes planus. The feet themselves should be examined from above, as well as from behind and from the side. A healthy person typically has about 5° of hindfoot valgus; in patients with PTTD, the valgus is increased

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and the forefoot abduction is also more pronounced.[2,5] The posterior tibial tendon should also be examined from above the medial malleolus to its insertion for pain with palpation and to assess swelling that is common in the first stages of PTTD.[7] In later stages the deformity can progress and pes planus may be visible.[8]

The diagnosis of PPTD can be made clinically based on history and objective testing. Characteristic findings of PTTD include loss of medial arch height, edema of the medial ankle, inability to resist force to abduct the foot, medial ankle pain with weightbearing, inability to rise on the toes without pain, and lateral subtalar joint pain.[7,8]

Clinical tests that are useful for diagnosis include:

- The "too many toes" sign (overpronation causes the patient to appear to have extra toes when viewed from behind)[8]
- Single- and double-limb heel rise[9]
- Plantar flexion and inversion of the foot against resistance[9]
- First metatarsal rise sign: Externally rotate the shank of the affected foot while the patient is weightbearing on both feet. The head of the first metatarsal will rise in the presence of PTTD.[10]


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Treatment

Treatment can begin in many cases with nonoperative treatment, which can include orthotic intervention,[11-13] immobilization in a short-leg cast or boot, and physical therapy.

Our multimodal treatment approach includes manual therapy, modalities focused on improving vascularization, therapeutic exercise (with an emphasis on eccentric contractions[4,12,13]), flexibility (stretching), and foot orthoses. We based this approach on the aforementioned evidence related to the mechanisms underlying PTTD and the effectiveness we have seen in clinical practice.

The most prolonged benefits of our approach have been changes in the biomechanics of the foot and ankle with the use of orthoses, which is consistent with the literature.[12,13] We have found success in the clinic with machine-grade orthotic devices that are comfortable, supportive, and can be posted to improve lower extremity biomechanics. Changing the biomechanics of the foot and ankle can improve efficiency and decrease trauma of tissue, particularly in patients with PTTD.[6,14]

Alvarez et al[12] and Kulig et al[13] suggested many patients with early PTTD can be effectively treated nonoperatively with orthotic management combined with exercise.

Alvarez et al demonstrated that patients with stage I and stage II PTTD had successful outcomes—including significant improvement in strength, biomechanics, and function at four months[12]—after completing this multimodal rehabilitation protocol:

- Wearing a short articulated ankle foot orthosis or foot orthosis
- Supervised high-repetition exercises, including plantar flexion exercises
- An aggressive high-repetition home exercise program that included gastroc-soleus tendon stretching

Success was defined as a strength deficit of no more than 10%, the ability to do 50 single-leg heel raises with minimal or no pain, the ability to walk 100 feet on the toes with minimal or no pain, and the ability to do 200 repetitions of the home exercises for each muscle group. After a mean of 10 visits over a median period of four months, 83% of patients had successful outcomes.[12]

Kulig et al also found that, while the use of foot orthoses and stretching was associated with significant improvement in pain and disability in patients with early PTTD, combining custom foot orthoses with eccentric and concentric progressive and resistive exercises accentuated those improvements.[13] The combination of interventions appears to be important for targeting the tibialis posterior muscle: In a previous study of patients with pes planus, the same group found the most effective and selective activation of the tibialis posterior during a closed-chain resisted foot adduction exercise occurred when the study participants wore arch-supporting orthoses.[15]

Clinical bottom line

PTTD is one of the most common problems of the foot and ankle in our patients who are runners and other athletes.[6] The tendon provides stability for the medial longitudinal arch of the foot. Depending on the patient's disease stage, PTTD can result in a flat foot (stage II, III, and IV) caused by inflammation or strain of the posterior tibial tendon. Early detection and intervention is key to mitigating progression. Early stage PTTD responds to a well-rounded treatment approach that includes orthotic management.

Frank Layman, PT, DPT, EdD, MTC, is an administrator and clinician at Randolph Specialty Group in Asheboro, NC, an adjunct faculty member of the Department of Physical Therapy at High Point University in North Carolina, and a vice president of business development for Tapout Fitness in Raleigh, NC. April Wilson, PTA, BS, CI, CKTP, IASTM, is a physical therapy assistant at Randolph Specialty Group and the owner of Footwise, a company that offers individualized foot fittings for athletes, also in Asheboro, NC.

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Support for dry needling builds among clinicians

Dry needling is gaining momentum as an alternative therapy for myofascial pain, and is supported by a small but growing body of research as well as anecdotal evidence. But the training and expertise required to perform the procedure has become a topic of debate.

By P.K. Daniel

In recent years, integrative medicine—the combining of conventional practices with alternative therapies—has become more popular in treating a variety of maladies. Dry needling, performed using acupuncture needles, is an East-meets-West modality for treating painful conditions related to the musculoskeletal and nervous systems that has also become more mainstream. Among the lower extremity applications for dry needling, with varying degrees of evidence-based success, are Achilles tendinopathy, plantar fasciitis, chronic lateral hip and thigh pain, and the prevention of pain after total knee arthroplasty.[1-4]

The technique, also known as intramuscular stimulation and trigger-point dry needling, uses a thin, monofilament needle, which can vary in length and gauge depending on the body part being worked on, to penetrate the skin and stimulate underlying muscular trigger points to treat conditions like myofascial pain syndrome.

Myofascial pain researching pioneer Janet Travell, MD, studied dry needling therapy for treating myofascial trigger points (MTrPs) and muscle dysfunction as early as the 1940s, and developed the trigger point model on which the therapy is based.[5] Modern dry needling, however, is credited to Czech neurologist Karel Lewit, MD, DSc, one of the founders of the Prague School of Rehabilitation and Manual Medicine, in 1979.[6] Lewit emphasized the needling effect was distinct from that of any injected substance. "In reviewing techniques for therapeutic local anesthesia of pain spots, it appeared that the common denominator was puncture by the needle and not the anesthetic employed," Lewit noted in his research.[6]

Lower extremity dry needling applications include Achilles tendinopathy, plantar fasciitis, chronic lateral hip and thigh pain, and pain after total knee arthroplasty.

Targeting trigger points

Although the actual mechanism by which dry needling works is unclear, its utilization is largely based on the trigger point model.

"Trigger points can produce local pain as well as referred pain," said John Mason, DPT, DSc, SCS, CSCS, a physical therapist and dry needling researcher currently practicing in the Fort Bragg, NC, area.

The intent is inactivation of the involved trigger point through

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Figure 1. Professional baseball player being treated with dry needling for distal hamstring tendinopathy. (Photo courtesy of Sue Falsone, PT, MS, SCS, ATC, CSCS, COMT.)

intramuscular stimulation with the needle, he said.

Jaime Salom-Moreno, PT, PhD, a professor in the Department of Physical Therapy, Occupational Therapy, Physical Medicine and Rehabilitation at the Universidad Rey Juan Carlos in Alcorcón, Spain, explained that a needle is inserted into discrete focal points of taut bands within the muscle and manipulated until local twitch responses (LTRs) are elicited. Once the first local twitch response is obtained, the needle is moved up and down 4 to 5 mm for 25 to 30 seconds.

"The LTR is an involuntary spinal reflex contraction of muscle fibers," he said. "The main theory presupposes the dysfunction on the endplate of the muscle, which could cause the onset of the pain and motor impairment. The effect of dry needling is to change the activity of endplate dysfunction."

Mason noted that trigger-point needling should be utilized in combination with stretching, joint mobilizations, strengthening, and neuromuscular re-education to help relax tight bands, normalize muscle tone, and improve the flow of neurochemicals in the affected tissue.

"One of the goals of dry needling is production of a localized twitch response within the muscle," he said. "It is believed that this twitch response may interrupt dysfunction of the motor endplate."

Mason published a case study in which a combination of trigger-point dry needling and exercises were utilized on a 16-year-old female ballet dancer who presented with a two-month history of

right posterior knee pain. She was treated with dry needling twice to the right gastrocnemius, soleus, and popliteus muscles, with 48 hours between sessions. Palpation identified the MTrPs that reproduced her primary symptoms. The patient also underwent an at-home exercise program (HEP) promoting lower extremity flexibility and hip stability. The HEP, which included daily stretches, got progressively more challenging over one month. There were one-month and three-month follow-ups.[7]

At the one-month follow-up, the dancer said she had complied with the HEP and had gradually resumed her intensive dance training program. At the three-month follow-up, she again reported being able to continue with her full-training routine without recurrence of symptoms. No additional treatment was needed.[7]

Evidence and experience

While extensive studies on dry needling have not yet been done, and practitioners acknowledge further research is necessary, there is some evidence of dry needling's effectiveness, said Salom-Moreno, who was the lead author of a 2014 study published in the *Journal of Manipulative and Physiological Therapeutics* on the effects of dry needling on stroke spasticity.[8]

"In the lower limb, there are few studies, but my experience in this area is very positive," he said.

Dry needling includes both superficial and deep techniques. While deep trigger-point dry needling targets mostly dysfunctional motor units, superficial needling targets primarily peripheral sensory nerve fibers, according to Peter Baldry, MD, who discovered the superficial technique in the early 1980s. Baldry has said the majority of his patients with MTrP pain are treated with superficial dry needling, while those with concomitant MTrP pain and nerve root compression pain may require deep dry needling, which differs in the needle manipulation and the neurophysiological effects.[9,10]

The objective of Salom-Moreno's study was to determine the effects of deep dry needling (DDN) on spasticity, pressure sensitivity, and plantar pressure in stroke patients. The researchers concluded that, after just a single session of DDN, both spasticity and widespread pressure sensitivity decreased. They also found that DDN was associated with changes in plantar pressure related to an increased support surface and a decrease in mean pressure.[8]

Leslie McCoy, LAc, DAOM, who is the chair of the Oriental Medicine department at Pacific College of Oriental Medicine (PCOM) in San Diego, also acknowledged the limited number of studies but pointed to the acupuncture literature as supporting the efficacy of dry needling. For example, a systematic review in the *Journal of Orthopaedic and Sports Physical Therapy* supported the use of acupuncture to manage musculoskeletal disorders of the extremities, including Achilles tendinopathy and plantar fasciitis.[11,12]

"Dry needling has a smaller evidence base using the words 'dry needling,'" McCoy said. "But clinicians performing dry needling can use some acupuncture studies to support efficacy, as they are essentially identical interventions."

Another Salom-Moreno-led study compared the combined treatment of trigger-point dry needling in the lateral peroneus muscle plus eight weeks of proprioceptive/strengthening exercises to proprioceptive/strengthening exercises alone in patients with painful chronic ankle instability. One month after the intervention, patients who received the combined therapy had better pain and

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function outcomes than those who did not receive dry needling.[13]

"In these cases, the patients who met protocol exercises and dry needling produced better results in pain and function," Salom-Moreno said.

Risks and side effects

As with any treatment, dry needling comes with potential risks and side effects, including soreness and bruising, local hemorrhages at the needling sites, infection, organ puncture, and syncope. The application involves pushing the needle, which can be up to 4 inches long to reach the affected muscle, through the skin to stimulate a trigger point. The process can be uncomfortable, as the practitioner must locate the exact point of pain (the MTrP) to relieve it effectively. This method differs from that of acupuncture, in which the needles are generally inserted a few millimeters below the surface, into the meridian pathway.

"Dry needling is painful, and acupuncture isn't," Salom-Moreno said. "This is an important consideration because the people who receive dry needling normally feel soreness for some hours afterward, in contradistinction to acupuncture, where patients are more emotionally influenced."

Mason concurred that dry needling can be painful.

"But that can vary from patient to patient based on multiple factors," he said. "The treatment technique involves targeting and inserting the needle directly into sensitive, painful muscle tissue, which may explain, in part, why it can be painful."

Pneumothorax is a dangerous potential complication in the upper trunk, but is unusual if practitioners have experience with dry needling, Salom-Moreno said. Nerve irritation is a potential risk anywhere in the body.

"In the lower limb, caution should be exercised with the neurovascular area or vessel injuries," Salom-Moreno said. "However, clinically, there are improvements in pain and functions."

Controversy can sometimes accompany newly adopted therapies, which has been the case with dry needling. The debate seems to center around the nomenclature. Some clinicians insist the practice is not acupuncture, while some acupuncturists insist that it is. This has to do with nonacupuncturists utilizing acupuncture needles, explained McCoy, a licensed acupuncturist. However, acupuncture needles were not always used for dry needling. Initially, a hollow bore needle (a hypodermic needle) was used by Travell in the 1940s, who later coined the term "myofascial trigger point" after learning that nodules can be present and refer pain to both muscle and overlying fascia.[5,14]

"Dry needling has been defined as a subset of acupuncture," said Sue Falsone, PT, MS, SCS, ATC, CSCS, COMT, who is an associate professor of athletic training at Still University in Mesa, AZ. Acupuncture utilizes traditional meridians based on Chinese medicine dating thousands of years, whereas dry needling is based on modern neuroanatomical science.

"In my opinion, the way a person uses a tool defines their profession," said Falsone, who owns Phoenix, AZ-based SF Dry Needling and S&F: Structure and Function. "In the same way using a hammer to hang a picture in my house does not make me a carpenter, or using a calculator does not make me an accountant, using a fine filiform needle does not make me an acupuncturist."

There are other attitudes about the two practices.

"As a technique, dry needling and acupuncture are the same,"

McCoy said. "The difference, though, lies in the paradigm that guides where the needles should be inserted. A physical therapist might look at a patient's hip and think, 'I need to stimulate the gluteus medius muscle.' An acupuncturist might look at the hip and say, 'I need to stimulate the shao-yang channel.' In fact, both clinicians will needle in the same region. The nomenclature will differ, however."

McCoy, who has worked with the integrative pain team at Rady Children's hospital in San Diego and whose unpublished doctoral work explored the use of manual needle techniques in the treatment of painful conditions, also said, "Acupuncture could also use needle insertion sites that are distal to the area needing attention. For instance, hip pain treatment might also use insertion of needles in the foot or hand."

Training

The issue for some in the acupuncture community regarding dry needling comes down to training and licensing.

"While acupuncturists train for four years to safely insert needles, some dry needling practitioners might only have training during a weekend seminar," McCoy said. "This has led to some controversy in the acupuncture camp, as acupuncturists are worried that an undertrained clinician with a needle might make the treatment look unsafe."

Novice dry needling practitioners can be too timid, and not fully engage the target tissue, leading to ineffective treatment, McCoy said. Conversely, a novice practitioner might be overly confident, and run the risk of damaging tissue or organs. Some of these concerns were debated in the comments section of an article in the May 2015 issue of *PT in Motion*.[15]

Mason said a common mistake of novice practitioners is treating only the location where the patient feels pain.

"Taking the whole body into account in terms of regional interdependence [how one region can affect other regions] is necessary when employing this modality and comes with increased experience," he said.

One of the foremost authorities on myofascial pain in Spain is clinical researcher and educational physical therapist Orlando Mayoral del Moral, PhD, of Hospital Provincial de Toledo. He said dry needling is very user-specific.

"It is important to have training and experience to get proficiency in its use," he said. "Not just for the use of the technique, but mainly for the correct diagnosis of the relevant trigger points."

He said a poor diagnosis of myofascial pain syndrome can lead to treatment of the wrong muscles and a painful, fruitless outcome.

Salom-Moreno agreed the success of dry needling is based in part on the technique of the practitioner. "The experience of the therapist and understanding in neurophysiological, biomechanical, and anatomical concepts are very important," he said. "However, the clinical examination and a good diagnosis will ensure that the approach is more effective. When the therapist demonstrates the above, dry needling is not difficult."

Salom-Moreno also agreed that failure to find the myofascial trigger point is a common mistake, along with incorrect palpation of the muscle.

"If you don't puncture in the dysfunction point, you don't have good results," he said. "Therefore, it is very important that the diagnosis and palpation are correct."

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Figure 2. Professional baseball player (not the same as in figure 1) with an anterior ankle impingement. Dry needling was performed at the syndesmosis, posterior tibialis, and ankle joint. (Photo courtesy of Sue Falsone, PT, MS, SCS, ATC, CSCS, COMT.)

Falsone concurred: "Every tool, in my opinion, is only as good as its practitioner. Patients with all types of pathologies and dysfunctions can benefit. It is important to find a dry needling practitioner or acupuncturist who is very familiar with your pain, disease, or dysfunction. My specialty is orthopedic and sports rehab and sports performance, so that is where and how I utilize dry needling."

Scope of practice

Multiple healthcare professionals, including physical therapists, chiropractors, certified athletic trainers, physicians, osteopathic physicians, naturopaths, and nurses, practice dry needling. So, on top of some acupuncturists worrying about the safety issue of under-trained clinicians needling, there are those who worry that allowing other professions to essentially perform acupuncture might limit access to patients for acupuncturists, and therefore their economic livelihood.[15]

"I don't share the same concern," McCoy said. "I think acupuncture—even dry needling—is a viable treatment option for so many musculoskeletal complaints that every patient should have access to it, whether they visit an acupuncturist or a well-trained physical therapist. I think this will actually expand the patient pool, not contract the patient pool. And, it will be of benefit to the patient."

But the concerns have led to efforts to stop the practice at the legislative level. The Chicago campus of PCOM, in conjunction with other alternative medicine organizations and the Illinois State Medical Society, was instrumental in getting the Illinois Department of Professional Regulation to agree in 2014 that the practice of dry needling is not in the scope of practice of physical therapy.

Although there are more than two dozen states plus the District of Columbia where dry needling has been determined to be within the scope of practice for a physical therapist, California, New York, and Hawaii have ruled that it is not. Other states are examining the issue. However, physical therapists (or physiotherapists) in South Africa, the Netherlands, Spain, Switzerland, Canada, Chile, Ireland, the UK, and New Zealand use it.

"Some will tell you there is no difference between the two [treatments], which is why there is so much controversy surrounding its use in healthcare by people who are not acupuncturists," said Falsone, who became the first and only female head trainer in Major League Baseball when she was promoted by the Los Angeles Dodgers in 2011.

Falsone thinks there is room for practitioners of both types.

"Personally, I have worked side by side with an acupuncturist, and it was wonderful," she said. "We would discuss, professionally debate, compare and contrast treatment interventions. We both had great results and worked very well together."

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Chronic ankle instability, gait, and muscle activity

New research suggests lower extremity clinicians should consider implementing gait training in combination with targeted strengthening of the peroneus longus and gluteus medius muscles to help restore normal gait patterns in patients with chronic ankle instability.

By Rachel Koldenhoven, MEd, ATC

Lateral ankle sprains are among the most common musculoskeletal injuries, not only in the physically active population[1] but also in the general population. Potential risk factors for sustaining a subsequent ankle sprain include a history of lateral ankle sprain,[2] poor postural control,[3] and an inverted foot position prior to heel contact during gait.[4,5] Regardless of the high prevalence of the injury, many individuals (40%-55%) do not seek medical attention following an initial lateral ankle sprain.[6,7] This lack of treatment may result in many long-term consequences, such as decreased quality of life,[8] decreased physical activity across the individual's lifetime,[9,10] and even an early onset of ankle osteoarthritis.[11,12]

Following a lateral ankle sprain, 40% of individuals develop a condition known as chronic ankle instability (CAI); the 60% who do not develop CAI are known as copers.[6] CAI is commonly characterized as having decreased self-reported function, repetitive bouts of instability or feelings of "giving way," and residual symptoms for at least one year following an initial lateral ankle sprain.[13] In general, copers are individuals who have a history of at least one lateral ankle sprain but do not have pain, weakness, or residual instability, and have returned to their normal activity level.

Many clinicians and researchers are aware that individuals who sustain lower extremity injuries tend to walk differently than healthy individuals who have never been injured. The foundation for our research stems from the basic understanding that individuals with CAI walk differently than individuals who have never sprained their ankle. Alterations and strategies adapted by CAI patients have been previously reported in terms of neuromuscular control,[14,15] plantar pressure,[15-17] kinematics,[5,18-21] and spatial-temporal measures during gait.[22] Clinicians should be aware that these alterations during gait exist and that they could potentially contribute to subsequent lateral ankle sprains or residual symptoms. It is important to first understand the general alterations that occur in individuals with CAI before attempting to intervene.

> Clinicians should be aware of distal and proximal neuromuscular strategies when attempting to improve gait mechanics in patients with chronic ankle instability.

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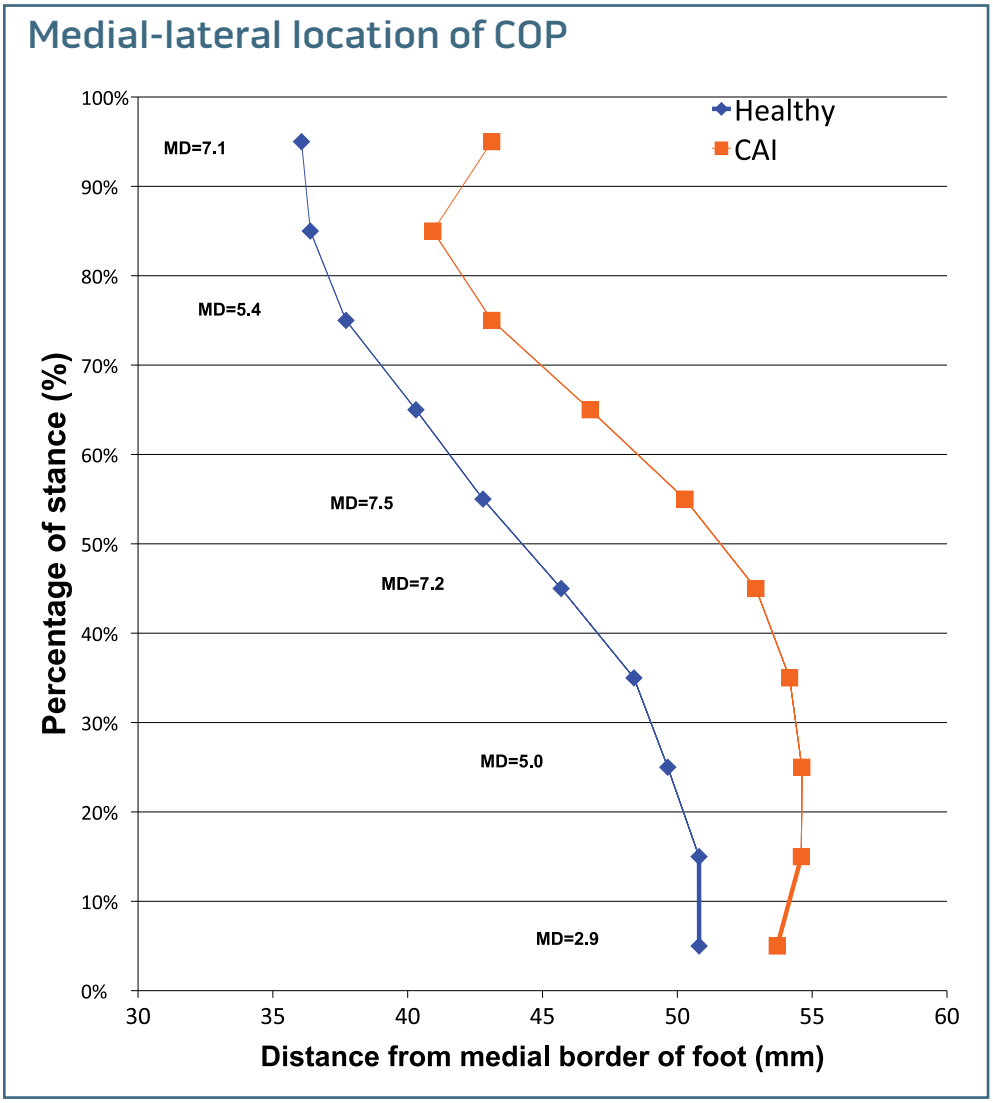

Figure 1. Medial-lateral location of COP throughout stance for healthy and CAI participants. MD = mean difference.

In addition to the lateral deviation throughout stance, we found the CAI group had higher average peak pressure and pressure-time integral in the lateral forefoot compared with the control group. This indicates the location of COP is not only more lateral throughout all of stance, but the forces are higher in the lateral forefoot in individuals with CAI. This could be problematic, because if individuals with CAI are walking more on the lateral aspect of their foot they will be closer to the edge of their lateral base of support. When the location of the COP falls outside that lateral base of support, a subsequent lateral ankle sprain or feelings of giving way may result. These findings may also help to explain why individuals with CAI demonstrate more rigid kinematic profiles during the stance phases of gait.[18] Having a laterally deviated COP may limit the degrees of freedom available throughout stance and limit the ability of individuals with CAI to respond to subtle changes.

We also identified differences in muscle activity between the CAI and healthy groups. For this study, we analyzed the muscle activation for the tibialis anterior, peroneus longus, medial gastrocnemius, and gluteus medius muscles. We looked at the muscle activation amplitude throughout the entire stride cycle. The stride cycle was split into the stance (1%-60% of stride cycle) and swing (61%-100% of stride cycle) phases of gait. This was then broken down further into 10% intervals during stance (to match the location of the COP for plantar pressure) and 25% intervals during the swing phase of gait.

We found significantly higher gluteus medius muscle activation in the individuals with CAI than the controls from 50% of stance through the first 25% of the swing phase (Figure 2). This increase in gluteus medius activation could potentially be a proximal strategy used by CAI individuals to compensate for a distally supinated foot position. CAI patients have been shown to walk with a 43% wider base of support than healthy individuals, which is thought to be a method of improving dynamic stability that may reduce the demand on the static and dynamic stabilizers of the ankle.[22] Our study is the first to identify altered gluteus medius muscle function during the gait cycle in individuals with CAI.

We also looked at the extent of activation for the time around initial contact by measuring the root mean square (RMS) amplitude for the 100 ms prior to initial contact (pre-IC) and the 200 ms following initial contact (post-IC). We identified significant differences

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General discussion of study and findings

The purpose of our study[23] was to simultaneously analyze muscle activation throughout the entire gait cycle and plantar pressure throughout the stance phase of walking gait in young adults with and without CAI. This was done to gain a more comprehensive understanding of the role of muscle activity and plantar pressure distribution in CAI gait pathomechanics. Previous studies have also looked at muscle activity, but the focus has been on analyzing muscle activity during the stance phase only, or a small time period around initial contact, but not throughout the entire gait cycle.[4,15]

We analyzed 17 individuals with CAI and 17 healthy individuals as they walked on a treadmill. Our primary outcome of interest was the medial-lateral location of the center of pressure (COP) at 10% intervals of stance. The location of the COP from 1% to 10 % of stance was condensed into one data point that represented the average location of the COP at 5% of stance. We continued this process for the entire stance phase to create 10 discrete data points.

Our results revealed the COP of the CAI group was significantly more lateral than the control group throughout the entire stance phase. At initial contact, the location of the COP in the CAI group was about 3 mm more lateral on average. During midstance, the CAI group's location of COP was more than 7 mm more lateral on average (Figure 1).

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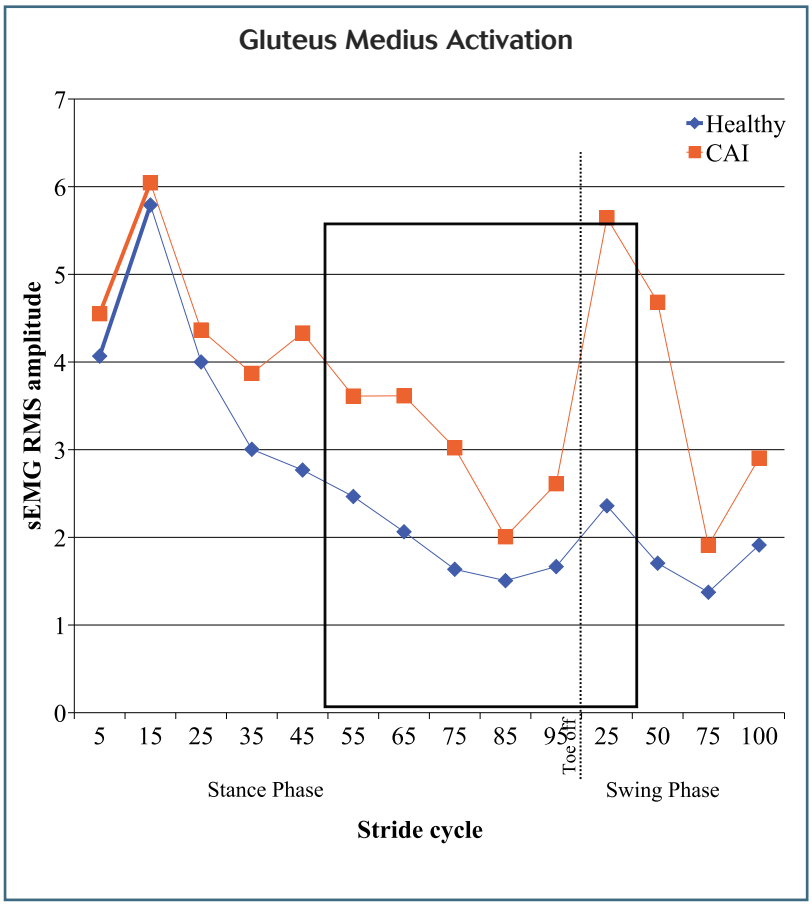

Figure 2. Gluteus medius surface electromyography root mean square (sEMG RMS) amplitude throughout entire gait cycle for healthy and CAI participants. Boxed area indicates significant differences between groups.

between the two groups for only the 100ms pre-IC (Figure 3). The CAI group demonstrated less anterior tibialis activation than controls, but greater activation for the peroneus longus, medial gastrocnemius, and gluteus medius muscles just prior to initial contact. These results may help explain the decrease in vertical foot-floor clearance and more plantar flexed position prior to IC demonstrated by individuals with CAI.[5,24,25]

Gait and CAI in the literature

The peroneus longus (PL) muscle is commonly studied in the CAI population. The PL is not only used to actively evert the foot, but also plays a role in pronation during the stance phase of gait. The PL also provides a great amount of dynamic stability for the lateral ankle.[26] In addition to our study, previous research has also identified alterations in the function of the PL in individuals with CAI. Feger et al[14] suggested that "preactivation may be a coping strategy that is effective for normal ambulation and allows individuals with CAI to complete functional tasks, but it may be ineffective in providing adequate dynamic stability to the lateral ankle to prevent injury." Our results are consistent with the hypothesis that the preactivation may not be effective, in particular our finding that plantar

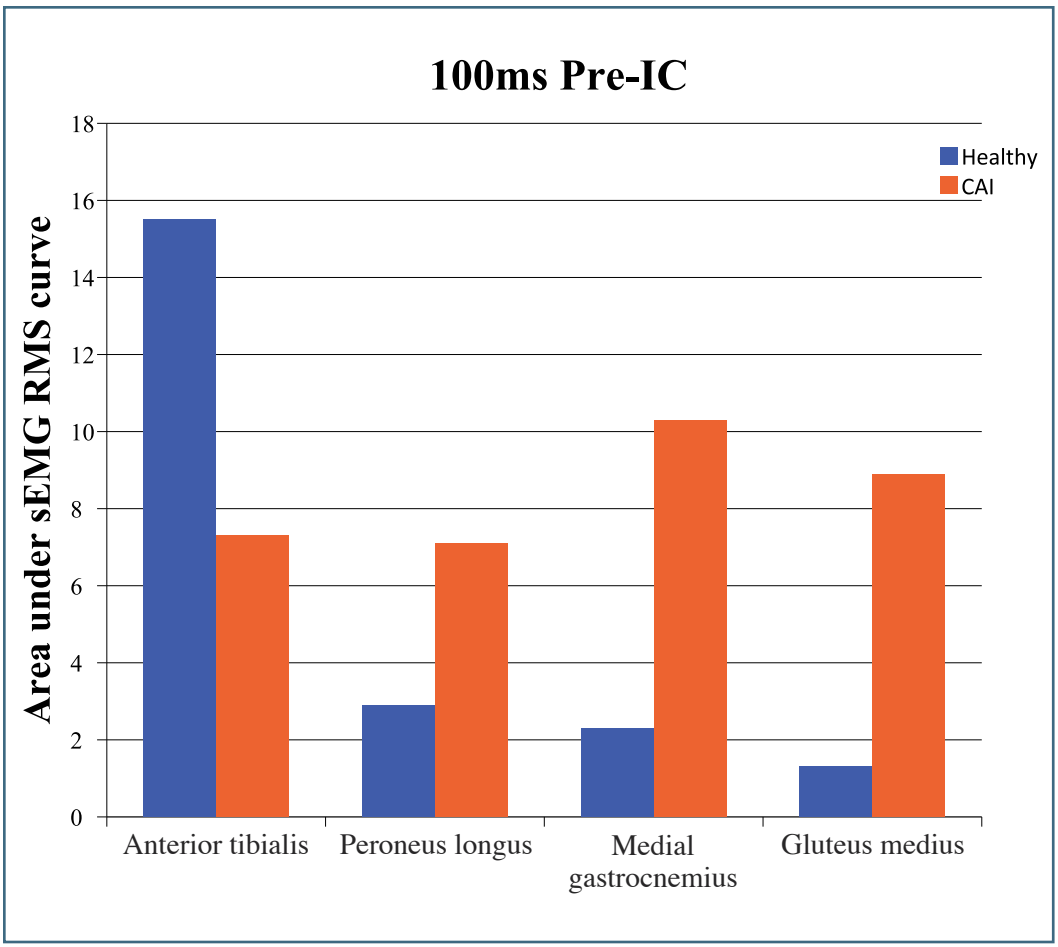

Figure 3. The area under the sEMG RMS curve 100 ms prior to initial contact for healthy and CAI participants.

pressures were lateralized throughout stance.

Previous studies involving this population have also identified differences in kinetics and kinematics. During running, individuals with CAI have a lateral shift in plantar pressure of the rearfoot during initial contact and a greater lateral COP trajectory during loading compared with controls.[27] During jogging, individuals with CAI have demonstrated increases in pressure located in the lateral midfoot and lateral forefoot.[17] An inverted foot position pre-IC[5] may manifest into the increased lateral loading[27] and laterally deviated COP trajectory[15] identified by previous studies and the lateral location of the COP throughout stance identified by our study.

Drewes et al[28] also identified more inverted foot positioning in individuals with CAI than in controls,

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but was the first study to observe that individuals with CAI may have a less coordinated movement pattern with regard to alterations in kinematics and joint coupling during terminal swing. Additionally, two studies have reported that individuals with CAI have less variability in shank and rearfoot coupling than controls[29] and less stride-to-stride variability during the stance phase.[18] These findings could indicate that individuals with CAI have a more constrained sensorimotor system than healthy individuals and are less able to adapt to changes.

Clinical implications

While descriptive studies are important for understanding the general alterations between the groups presented, it is also important for clinicians and researchers to understand how a variety of interventions can be used to target those deficits. Several studies have used a variety of intervention strategies to target deficits seen in individuals with CAI.[30–33] Donovan et al[30] recently used auditory feedback as an intervention to shift plantar pressure medially, which caused an increase in PL and medial gastrocnemius activation following initial contact. The same group has also identified an increase in PL activation while walking associated with two different destabilization devices in individuals with CAI compared to healthy individuals.[31]

Although Donovan et al used novel and innovative techniques, studies have also been conducted looking at more traditional intervention techniques commonly employed by clinicians. Chinn et al[32] studied the immediate effects of using ankle tape for support in individuals with CAI and found decreased plantar flexion and inversion during the gait cycle compared with no tape, which suggests a more neutral foot position during walking. A similar study by Herb et al[34] found that taping decreased the variability of coupled motion in both healthy and CAI groups. Barlow et al[33] identified a decreased amplitude for the PL and delayed activation of the tibialis anterior, PL, rectus femoris, and gluteus medius muscles when individuals with CAI were wearing a brace during walking. Collectively, these findings suggest taping and bracing interventions may be beneficial for protecting individuals with CAI from future sprains.

Lastly, a study by McKeon et al[35] studied the effects of a four-week progressive balance training program in individuals with CAI. The clinical take-home message was that the intervention "improves the control of the shank and rearfoot during walking, but not jogging in those with chronic ankle instability."

Conclusions

Individuals with CAI demonstrate alterations during walking. Clinicians and researchers should understand these deficits and attempt to address them during rehabilitation. There are currently no evidence-based recommendations for gait retraining in individuals with CAI, but clinicians should be aware of distal and proximal neuromuscular strategies when attempting to improve gait pathomechanics in CAI patients. Clinicians should consider implementing gait training in combination with targeted strengthening of the peroneus longus and gluteus medius muscles to restore normal gait patterns. ler

Rachel Koldenhoven, MEd, ATC, is a doctoral student at University of Virginia, Department of Kinesiology - Sports Medicine, in Charlottesville.

Disclosure: No conflicts of interest or disclosures to report in relation to this review.

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Reducing postoperative thromboembolism risk

Preventing deep venous thrombosis and pulmonary embolism after lower extremity surgery can involve pharmaceutical therapies or mechanical interventions. The type of prophylaxis used depends on the type of surgery, pre-existing risk factors, and patient preference.

By Barbara Boughton

Venous thromboembolic events (VTE)—a category that includes deep vein thrombosis (DVT) and pulmonary embolism (PE)—are some of the most serious complications of lower extremity surgeries, particularly those involving the knee and hip.

Without prophylaxis, the risk of asymptomatic DVT after total hip arthroplasty (THA) ranges from 40% to 60%; after total knee arthroplasty (TKA), the incidence ranges from 40% to 85%.[1]

Prophylaxis for VTE after surgery ranges from the complex to the simple—from injectable anticoagulants such as low molecular weight heparin to intermittent pneumatic compression devices and foot pumps. Compression sleeves and stockings are also used. The type of VTE prophylaxis often depends on the type of surgery, a patient's pre-existing risk factors, and sometimes patient and clinician preference.

The good news is that the push to reduce VTE has led to more diligence around VTE prophylaxis.

"Over the past four to five years, more patients are receiving prophylaxis after lower extremity surgeries such as TKA and THA. And there's an increased emphasis on assessing patients' risk factors and choosing the right treatment for individual patients—and documenting the reasons for these choices," said Darryl Kaelin, MD, associate professor of physical medicine and rehabilitation at the University of Louisville in Kentucky and current vice president of the American Academy of Physical Medicine and Rehabilitation.

While medications often play a central role in prophylaxis after THA and TKA, early weight-bearing and mechanical methods can play a crucial role too. A patient's pre-existing risk factors for either VTE or bleeding events are likely to be major considerations. Absent any pre-existing risk factors, however, the choice of VTE prevention can also be driven partly by patient preference.

Risk stratification protocols are currently under study, and have been shown to be effective for choosing the right method of VTE prophylaxis for individual patients.

Risk assessment

An important first step in prescribing VTE prophylaxis is to accurately and thoroughly assess a patient's risk for VTE as well as bleed-

Continued from page 45

ing events. Risk stratification protocols are currently under study, and have proven to be an effective means of choosing the right protocol for individual patients. In one study of a risk stratification protocol,[2] for instance, 3143 patients undergoing total joint arthroplasties were classified as having either "routine" or "high" risk for VTE. Patients classified as having routine risk (70.7% of patients) received mobile compression devices for 10 days and aspirin twice daily for six weeks. High-risk patients (29.3%) took warfarin for four weeks and wore compression stockings for six weeks.

Results indicated that the rate of symptomatic VTE in the routine-risk versus the high-risk cohort six weeks postoperatively was .7% compared with .5%. The rate of major bleeding events, understandably, was significantly lower in the routine-risk group (.4%) versus high-risk patients (2%).

> Early postoperative mobilization is a tried and true method for increasing blood flow, but how early patients can bear weight depends on the type of procedure.

"The use of a risk stratification protocol allowed the avoidance of more aggressive anticoagulation in 70% of patients while achieving a low overall incidence of symptomatic VTE," the authors of the study concluded.

Some of the strongest risk factors for VTE are a personal history of VTE, hypercoagulability, and active or recent cancer.[3,4] Other risk factors include obesity, advanced age, diabetes, and varicose veins. Prolonged immobilization is also a strong risk factor for VTE.

Clinicians also use the Caprini Deep Vein Thrombosis risk score to predict the clinical incidence of DVT. Validated in clinical trials involving more than 8000 patients,[5] it considers age; gender; type and length of surgery (including THA or TKA); pre-existing patient characteristics such as previous heart attack, lung disease, and blood clots; and the time for which the patient will be confined to bed rest. Other risk factors to consider include a history of autoimmune disorder, according to clinicians interviewed by *LER*.

"You have to look at every patient as having risk if they're undergoing lower extremity surgery," said Marlin Schul, MD, MBA, a dedicated deep vein specialist at the Lafayette Regional Vein & Laser Center in Indiana. "Patients who are high risk will need some sort of pharmacologic prophylaxis, while those who have a low or intermediate risk may need at least some combination of compression and early mobilization."

Mechanical methods

Early mobilization is one of the most tried and true methods for increasing blood flow and preventing blood clots, but how early patients can bear weight depends on the surgery.

"Still, even with total knee or total hip arthroplasties, we try to get patients up the same day or the next day after their surgery. It's the best way to reduce the risk for developing a blood clot," Kaelin said.

Guidelines published by the American College of Chest Physicians (ACCP) suggest the use of medications over mechanical methods, but intermittent pneumatic compression (IPC) devices are also valuable in preventing clot formation, according to the guidelines.[6] In patients receiving pharmacologic prophylaxis after major orthopedic surgery, the ACCP guidelines also suggest using an IPC device during the hospital stay. Patients at increased bleeding risk should also use an IPC device after they leave the hospital for 10 days to a month, according to the ACCP guidelines.

Guidelines from the American Academy of Orthopaedic Surgeons (AAOS) also note that patients who are undergoing elective TKA or THA and have had a previous VTE should receive both pharmacologic prophylaxis and mechanical compressive devices.[7]

Many surgeons also apply a compression pump or device during surgery—but on the opposite limb from that undergoing surgery.

"It prevents the blood from pooling, and helps pump blood back toward the heart. Using these mechanical devices during surgery also allows the soft tissue to release plasma thromboplastin factors that reduce the risk for clotting," said Louis Kwong, MD, professor of orthopaedic surgery at the David Geffen School of Medicine at UCLA and chair and medical director of the Orthopaedic Clinics at the Harbor-UCLA Medical Center in Los Angeles.

Once outside the hospital, some patients also do well with a mechanical compressive device or foot pump, Kwong said.

"A number of studies demonstrate the clear effectiveness of mechanical methods, but patient compliance can be an issue after the patient returns home," he said. "Some patients are very accepting of the mechanical devices—and even prefer them to medication—but others find them cumbersome and uncomfortable, especially in hot and humid weather."

If the patient is not weightbearing, an IPC device or foot pump has to be worn for 18 to 22 hours a day for at least two weeks, and that can be an onerous task for some patients—especially since the devices have to be plugged into the wall, which limits mobility. Some IPC devices can be carried in a pouch with the patient, but lugging the device everywhere one goes is seen as a major inconvenience by some patients, Kwong said.

"If compliance starts to fall off, either because the patient does not wear the device or doesn't wear it for the required number of hours, then the patient is put at risk for a DVT," he emphasized.

Still, for patients who are immobile and need to use a mechanical device to prevent DVT, an IPC device can be the method of choice if a compression stocking or sleeve cannot fit over the foot and ankle after surgery, Schul notes. More convenient stockings and sleeves can sometimes be applied before surgery and can be left on afterward—but that's not always the case, he added.

An IPC device can be hooked up in the recovery room by either the surgeon or the nurse.

"It's important to aim for 100% compliance in the recovery room, because it's the highest risk time for DVT—by having the doctor or nurse hook up the pump. That's also an ideal time to reinforce the need for compliance. If it's not on, an intermittent pneumatic compression won't do much good," says John Morris, MD, an orthopedic surgeon and staff physician at St. Joseph Mercy Hospital in Ann Arbor, MI.

The advantage of these devices is that they carry no risk for bleeding, and for some patients—even those at average risk for bleeding events—that can be a relief, Morris said. The cost of these devices, while not always covered by insurance, is also not prohibitive. In Michigan, they can be rented for several hundred dollars for several weeks, he said.

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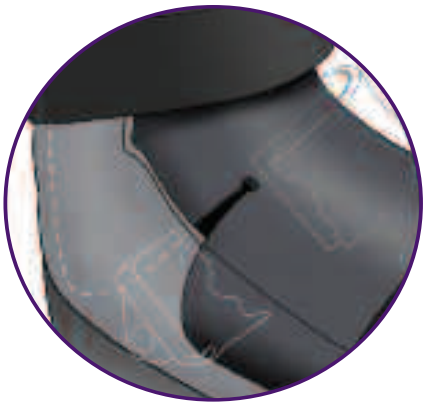

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One advantage of mechanical methods such as pneumatic compression devices, as well as compression stockings, is that they can facilitate early mobilization. Because these methods reduce swelling, studies show that patients are more likely to be up and walking earlier in the recovery period.[8]

Compression stockings

Since compression stockings reduce the risk for postoperative swelling and thus encourage earlier weightbearing, the result may be a decreased risk for DVT. Compression stockings are usually used in combination with other methods—either medication or early mobilization, depending on the patient's risk factors and surgery. Their benefits include practicality and convenience—if they can be fit over the foot and leg, according to Schul.

At the same time, studies on the efficacy of compression stockings for preventing DVT events have been conflicting. One explanation may be that studies on compression stockings as DVT prophylaxis have been subject to small sample bias and have not adequately controlled for lack of patient compliance, according to at least one review.[9]

Yet, patient compliance with compression stockings often depends on education and ease of use, research has revealed. A recent study on elastic compression stockings, for instance, found that patients were willing to wear the stockings after DVT to prevent post-thrombotic syndrome (PTS) for an extended time—up to one year—if they were educated about PTS risk reduction and could put on the stockings themselves.[10]

"These rather simple interventions could improve compliance," the authors noted.[10]

Incorrectly sized stockings can also cause proximal indentation, which can interrupt venous return. However, recent research indicates that carefully sizing stockings and measuring the pressures underneath them can significantly reduce the risk for proximal indentation. In one study, such a protocol significantly reduced the incidence of proximal indentation among 57 TKA and THA patients wearing compression stockings, from 53% to 19%.[11] The incidence of incorrectly sized stockings also fell significantly, from 74% to 34%.

Foot and ankle surgeries

The question of whether VTE prophylaxis should be used after surgery, and which method is best, is more unsettled with regard to foot and ankle surgeries than THA and TKA. According to guidelines from the American Orthopaedic Foot and Ankle Society, the assessment of patient risk factors for VTE can depend at least partly on the procedure performed.[12] And the correlation of patient risk factors with VTE from foot and ankle procedures has not been robustly investigated. Mechanical prophylaxis for foot and ankle procedures can range from elastic compression stockings to foot pumps and IPC devices, but the true efficacy of these modalities for preventing VTE after foot and ankle surgeries is as yet unknown, the guidelines note.

Chemical prophylaxis has also not been investigated thoroughly in the setting of foot and ankle surgeries. Some studies have found that medication-based interventions have negligible effects on preventing thromboembolic events after foot and ankle procedures.[13] The ACCP even suggests no prophylaxis rather than pharmacologic preventive methods in low-risk patients with isolated lower leg

injuries (or surgical procedures) that require immobilization.

The American College of Foot and Ankle Surgeons' (ACFAS) Clinical Consensus Statement on preventing VTE after foot and ankle surgery recommends that chemical prophylaxis for VTE after foot and ankle surgeries should not be used routinely.[14] Instead, the clinician should consider each patient's risk for both VTE and for bleeding events that could stem from prophylactic medications, according to the statement.

Patient characteristics and clinical history, as well as the length of immobilization, should be carefully weighed when deciding upon VTE prevention, according to the ACFAS consensus statement. Immobilizations with the most potential for VTE risk are those that last more than four weeks, are rigid, or are coupled with other patient risk factors, the guidelines note.

Despite these guidelines, there is still a lack of clinical consensus about preventing VTE after foot and ankle surgery—particularly for patients without clear risk factors. A recent poster at the 2016 annual meeting of the American Podiatric Medical Association in Philadelphia highlighted the diverging opinions and practices among foot and ankle surgeons for prevention of DVT after surgery.[15] In the study, 785 ACFAS members responded to a survey about current practices in DVT prevention and treatment. According to the survey, the most common form of DVT prophylaxis after surgery was low molecular weight heparin, but for 30% of respondents it was a compression device or stockings, and, for nearly a quarter of respondents (23%), it was aspirin alone. There was also wide variation in factors influencing clinician's decisions about postoperative chemical prophylaxis, but most respondents (78%) said a patient's history of DVT or PE routinely affected their decisions.

"There really is no scientific consensus about how to treat patients after foot and ankle surgery to prevent DVT—or whether to use any preventive method at all," said Christopher DiGiovanni, MD, chief of foot and ankle surgery at Massachusetts General Hospital in Boston and at nearby Newton Wellesley Hospital. "As a result, we either overtreat, undertreat, or, if we are lucky, we get it right."

To address the lack of robust research in this area, DiGiovanni is working to obtain funding for a $12 million international study with 27,000 patients to analyze the effects of no treatment, aspirin, or anticoagulants after foot and ankle surgery. Although mechanical methods are not being studied, the study—if funded—should shed some light on the question of whether medications are useful, he said.

"My preference as an individual clinician is to give patients low-dose aspirin and also get them up and moving as soon as possible after the surgery. Once they are weightbearing, then I prefer to stop the medications," DiGiovanni said.

The study could also help determine the extent to which a patient's individual risk factors for DVT and bleeding events should factor into the prophylaxis equation, he said.

"If the study I'm working on gets fully funded, we should be able to stratify patients based on their risk factors to different preventive methods," DiGiovanni said. "And that will provide some guidance about what type of prevention should be used."

Barbara Boughton is a freelance writer based in the San Francisco Bay Area.

References are available at lermagazine.com.

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Step-rate manipulation and foot-strike pattern

In distance runners, step-rate manipulation of at least 10% above a runner's preferred rate may be an effective clinical gait retraining method to decrease the severity of foot inclination angle at heel strike and possibly encourage a transition to a non-heel-strike pattern.

By Darrell J. Allen, PT, DPT, MS, SCS, CSCS; Hollie Heisler, PT, DPT; and Jennifer Mooney, PT, DPT

The popularity of running in the US is at an all-time high. With the growing number of runners, especially those running high mileage in preparation for half and full marathon distances, injuries related to running have also been on the rise. In a 2007 systematic review, Van Gent et al reported an incidence of running-related injuries ranging from 19.4% to 79.3%.[1] As more runners seek care for running-related injuries, it becomes increasingly important that healthcare and rehabilitation professionals are equipped to provide care specific to these injuries.

In recent years, researchers have examined the impact forces associated with running and have shown—or at least provided a theoretical basis to suggest—that higher impact forces are a potential cause of various running-related injuries.[2-4] It's well established that impact forces at the knees and hips are typically higher in runners who use a rearfoot-strike (RFS) pattern than those who use a midfoot- or forefoot-strike pattern.[5-8] Research also shows shod runners typically strike with the heel first, while barefoot runners tend to run with a nonheel-strike pattern. Changing foot-strike pattern from a RFS pattern to a midfoot- or forefoot-strike (FFS) pattern through gait retraining may be one way to reduce impact forces and the risk of running-related injuries.[9,10] Up to 96% of recreational runners who run in traditional running shoes have been reported to be heel-strikers, making this a relevant issue for rehabilitation professionals.[11,12]

> Increasing step rate is more likely to positively affect foot inclination angle than foot-strike pattern in habitual heel strikers who run in traditional cushioned shoes.

Gait retraining

Several methods of running-gait retraining to modify foot-strike pattern have been examined in the literature.[13] Barefoot running has been one of the most prominent methods to accomplish a change from a RFS pattern to a FFS pattern. It has been well documented that barefoot running tends to support a more forefoot-based foot-strike pattern, decreased contact time, and a quicker step rate compared with running in traditional cushioned shoes, which tends to support a heel-strike pattern.[14-16] Hatala et al, however, found not all

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Table 1. Foot-strike pattern as a function of step rate

	Foot-strike pattern (%)			P-values			
Factor	Heel (N=137)	Midfoot (N=15)	Forefoot (N=8)	Overall	vs Preferred	vs 5%	vs 10%
Step rate				< .001			
▪ Preferred	40 (100)	0 (0)	0 (0)				
▪ 5%	36 (90)	3 (7.5)	1 (2.5)		.059		
▪ 10%	33 (82.5)	5 (12.5)	2 (5)		.013	.10	
▪ 15%	28 (70)	7 (17.5)	5 (12.5)		.001	.005	.021

habitually barefoot people prefer running with a FFS pattern and that factors other than shoe preference may dictate foot-strike pattern.[17] The feel and comfort of barefoot running is very different than running in shoes and may be difficult for many runners to get used to.

Minimalist shoes have become popular in recent years, and marketing of these shoes has suggested their benefits to runners are similar to those of barefoot running. Rice et al in 2016 examined the component and the result of ground reaction forces and instantaneous load rate during running in three groups of runners: habitually shod runners with a RFS pattern, habitually shod runners with a FFS pattern, and those who habitually run in minimal shoes and have a FFS pattern. The results suggested running with a FFS pattern in standard shoes resulted in similar load rates as running with a RFS pattern in standard shoes. However, resultant load rates were significantly lower when running with a FFS pattern in minimal shoes.[18] It may be expected that those individuals who are not already FFS runners may experience higher load rates, at least initially, if they transition to minimalist shoes.

Other research has shown runners who switched to minimalist shoes did not acutely change their foot strike pattern from a heel-strike pattern to a nonheel-strike pattern and, in fact, experienced higher loading forces than when running in traditional shoes.[19] Bergstraa et al reported increased plantar pressures in women who ran in minimalist shoes and no difference in landing patterns between running in minimalist versus traditional shoes.[20] Finally, a study by Kernozek et al in 2014 looked at loading in minimalist footwear over a four-week period compared with one session. They also found higher plantar pressure loading in minimalist shoes, with the specific location of the higher pressures dependent on foot-strike pattern.[21]

These findings collectively suggest that runners who wish to continue to run in traditional running shoes may need to look at other methods of changing their foot-strike pattern to reduce impact forces.

Step-rate manipulation was described by Heiderscheidt et al in 2011; they found a significant reduction in impact forces in distance runners with as little as a 5% increase in step rate.[4] Multiple authors have also reported a reduction in impact forces through increased cadence or step rate.[6,22-24] The research by Heiderscheidt et al showed increasing step rate in shod runners was associated with reduced kinematic variables, including step length, center of mass vertical excursion, and foot inclination angle. Reduction of these variables was associated with decreased impact forces, which could theoretically reduce injury risk for distance runners.

Step-rate manipulation has also been presented as an easy and practical method of running-gait retraining in the clinical environment, since it can be accomplished using metronome cues and faded feedback methodology. While past research has documented many positive changes in running kinematics related to step-rate manipulation, it had not been examined as a method to change foot-strike pattern, nor had the percentage of step-rate increase needed to make this change been established.

Our research

The purpose of our study was to examine step-rate manipulation as a potential method to change foot-strike pattern from a heel-strike to a nonheel-strike pattern. A secondary purpose was to describe the effect of step-rate manipulation at specific percentages above a runner's preferred step rate on foot inclination angle at initial contact.

We measured foot inclination angle, using the Medical Motion Video Analysis Software, as the angle between the treadmill and the sole of the foot, consistent with previous studies that have reported on this measure.[5,29]

Our study had 40 volunteer runners who were heel-strikers and had a weekly mileage of at least 10 miles. All were analyzed while wearing their own traditional running shoes. We confirmed runners as heel strikers during the warm-up periods on the treadmill. Although six runners claimed to be midfoot strikers on the day of testing, we confirmed on review of the data that they were heel-strikers. Each participant's step rate was determined at his or her preferred running pace, and a metronome was used to increase step rate above the preferred rate by 5%, 10%, and 15%; these conditions were randomized.

We used 2D video motion analysis to determine foot-strike pattern and measure foot inclination angle at initial contact during running for each step-rate condition. We classified foot-strike patterns into three categories consistent with Lieberman et al: rearfoot, when the heel is the first region to contact the ground; midfoot, when the heel and ball of the foot simultaneously contact the ground; and forefoot, when the ball of the foot contacts the ground before the heel.[14] We looked at foot strike during one segment of the run, not throughout the entire run.

Our study showed there was an overall difference and a significant, increasing number of nonheel strikers as the step rate increased: The preferred rate + 15% had significantly more nonheel strikers than the preferred rate and preferred rate + 5% conditions; the preferred rate + 10% condition had significantly more nonheel strikers than the preferred rate. Table 1 compares all three foot-strike patterns at the different step rates.

Our study also found a statistically significant reduction of the mean foot inclination angle as step rate increased (Table 2). The + 5% condition had a 3.34° smaller angle on average than the preferred step rate. The angle in the preferred rate was significantly greater than all other conditions, while the + 15% condition had a significantly smaller angle than all other conditions.

In summary, with regard to both the foot-strike pattern and foot inclination angle analysis, significant changes were associated with increases in step rate. For the foot-strike pattern, an increase of at least 10% in the step rate was needed to show a significant increase

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Table 2. Foot inclination angle at initial contact as a function of step rate

	Foot inclination angle		vs Preferred		vs 5%		vs 10%	
Factor	Mean (95% CI)	P-value	Mean (95% CI)	P-value	Mean (95% CI)	P-value	Mean (95% CI)	P-value
Step rate		< .001						
▪ Preferred	13.6° (11.6°, 15.6°)							
▪ 5%	10.3° (8.23°, 12.3°)		-3.34° (-4.72°, -1.96°)	< .001				
▪ 10%	8.77° (6.74°, 10.8°)		-4.83° (-6.67°, -2.99°)	< .001	-1.49° (-2.88°, -.11°)	.035		
▪ 15%	6.04° (4.01°, 8.07°)		-7.56° (-9.69°, -5.44°)	< .001	-4.22° (-6.06°, -2.38°)	< .001	-2.73° (-4.12°, -1.35°)	< .001

Comparisons of foot inclination angles are shown. Negative numbers represent reductions of foot inclination angle.

in the number of nonheel strikers. For foot inclination angle, significant decreases in the angle were observed with even 5% increases in step rate.

Clinical implications

The intent of our study was to determine whether step-rate manipulation alone was enough to change foot-strike pattern in shod recreational distance runners. We found increasing step rate above the runner's preferred rate by 10% was successful in changing foot-strike pattern from a heel-strike to a midfoot- or forefoot-strike pattern in 17.5% of the runners, while increasing step rate by 15% changed foot strike pattern in 30%. These results suggest step-rate manipulation alone may be an effective way to change foot-strike pattern in a small percentage of shod distance runners.

Although this is a statistically significant change, it does represent a relatively small percentage of the overall population. The majority of the runners in this study continued to run with a heel-strike pattern under all step-rate conditions. This suggests step-rate manipulation may be helpful to change foot-strike pattern in a small percentage of shod recreational runners, but that other methods of changing strike pattern may be more effective for runners as a population.

One of our observations, though not statistically analyzed, was that many runners who changed foot-strike pattern had a very small foot inclination angle at initial contact at their preferred step rate. These individuals may have an easier transition to a midfoot- or forefoot-strike pattern with an increased step rate than those who foot strike with a larger angle of inclination.

A limitation of our study was that it was performed for just one training session and the participants did not have a chance to practice running at these step rates. It may be that step-rate retraining may be more effective in changing foot-strike pattern over a longer period, including in those individuals who have larger foot inclination angles at initial contact.

Another finding of our study was that the foot inclination angle significantly decreased as step rates increased, which supports results of past research.[7] Others have shown that, as foot inclination

angle decreases, ground reaction forces and knee joint loads at initial contact are reduced.[25] Our findings suggest, then, that reducing foot inclination angle by increasing step rate at least 5% above a runner's preferred rate may have beneficial effects on impact forces, potentially reducing injury risk.

Our findings also suggest increasing step rate is more likely to have a positive effect on foot inclination angle than to prompt a change in foot-strike pattern in habitual heel strikers who run in traditional shoes. Clinical rehabilitation professionals can use step-rate manipulation above preferred to potentially change foot-strike pattern, but more likely to reduce the foot inclination angle or the severity of the heel strike in hopes of reducing impact forces and having a positive effect on injury rehabilitation or prevention.

Finally, we noted the 5% and 10% above preferred conditions were typically easy for the participants to match, and that only the 15% above preferred condition was an initial challenge for some participants. We agree with Heiderscheidt et al that the perceived increase in effort for the participants, especially at the + 15% condition, had more to do with attentional focus to achieve a novel task rather than a true increase in metabolic cost.[5,27-29] This would suggest that, while increasing step rate above one's preferred rate—especially at rates as high as + 15%—may seem challenging at first, practice would reduce the attentional focus and perceived exertion. Allowing step rate increases to be phased in gradually into the clinical environment would potentially help to reduce this change in perceived exertion for the runner.

Conclusions

Step-rate manipulation has been shown in the literature to be an effective means of reducing impact loading by changing sagittal plane variables such as stride length, center of mass vertical excursion, knee flexion angle at initial contact, and foot inclination angle.[5,25,26] In addition, it's also easy to implement in the clinical rehabilitation setting. For rehabilitation professionals seeking to reduce impact forces and rehabilitate or prevent running-related injuries, manipulating step rate can be done quickly with a simple metronome while an individual runs either on a treadmill or over ground.

Step-rate manipulation may be effective in changing the foot-strike pattern of recreational runners wearing traditional running shoes from a heel-strike to a midfoot- or forefoot-strike pattern, but probably in a relatively small percentage of runners. If changing foot-strike pattern is the primary goal, other methods may be needed.

The primary benefit of step-rate manipulation may be the reduction of foot inclination angle at initial contact, rather than a change in the actual foot-strike pattern. Step-rate manipulation of at least 10% above a runner's preferred rate may be an effective clinical gait retraining method to decrease the severity of heel strike and possibly assist a runner to transition to a nonheel-strike pattern. ler

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Custom-milled Orthotic Flip-flops

Footmaxx now offers custom-milled orthotic flip-flops. The orthotic flip flops are hand-crafted from durable materials, including a slip-resistant rubber sole, to support and stabilize the feet and lower extremities. Women's styles include Rio, with rhinestones inlayed in a single-stitch toe thong, and the Monaco, with a woven black strap that slips comfortably between the toes. Men's styles include the Malibu, with a woven jute strap, and the Barcelona, a rugged leather look in teak. Because they are custom made, these Footmaxx flip-flops can accommodate leg-length inequalities and different sized feet.

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FC2 Flexion Control Ankle Joint

Lower Extremity Technology has retooled the FC2 Flexion Control Ankle Joint to simplify fabrication. The multi-axis hinge offers 70° of full range of motion. The new design features an improved hinge axis for strength and durability, and updated casting for more support around the ball on the distal plate. The FC2 is made in the US of high-quality stainless steel, which is precontoured to save time and provide a low-profile finish. The key to the proprietary ball-and-socket axis is that it is self-aligning up to 26°, which minimizes axis stress while maximizing positioning options. The hinge has a 185-lb weight limit.

Lower Extremity Technology
888/928-9322
fc2ankle.com

Microfiber Shades Now in Heather

For people who need to wear graduated compression every day but want to add a pop of color to their wardrobe, Sigvaris North America is launching two fun new additions to the Microfiber Shades line of compression socks—navy heather and graphite heather socks. Both new colors are available in calf-length socks for men and women, with a closed toe and 15-20 mm Hg compression level, along with existing colors pink stripe, onyx stripe, graphite stripe, and dark navy stripe. The pink stripe, onyx stripe, and dark navy stripe are also available in the 20-30 mm Hg compression level for men and women.

Sigvaris
800/322-7744
sigvarisusa.com

Pro-Roller Soft Half

OPTP has added a new foam roller to its elite Pro-Roller line. The Pro-Roller Soft Half measures 36" in length and 3" in diameter. The roller's unique shape is flat on one side and round on the other. Using the flat side down provides improved stability for balance training and beginning Pilates use, while using the rounded side down allows for more dynamic, challenging exercise. The Pro-Roller Soft Half features a lightly textured, soft compression that is designed to be gentle on tight areas. Despite the soft density, the roller's durable, heat-molded foam technology helps it to maintain its shape, even with heavy use.

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Anatomical Concepts Abby AFO

The Abby Articulating Ankle Foot Orthosis (AFO) from Anatomical Concepts is a multifunctional, posterior dual-jointed device for the early stages of rehabilitation. With a stable base of support and a new nonskid low-profile plantar surface, it is designed to replicate the biomechanical effects of a semi-rigid or posterior leaf spring AFO. Foot length, calf height, plantar/dorsiflexion, and varus/valgus alignment can all be adjusted. Functional knee and ankle joint positioning helps facilitate clearance during swing and knee stability during stance. The Abby includes a heat-moldable foot orthosis. An open toe shoe is also included.

Anatomical Concepts
800/837-3888
anatomicalconceptsinc.com

Cascade DAFO Creation Station

Cascade DAFO announces the launch of the Creation Station for decorating custom dynamic ankle foot orthoses (DAFOs). With this new online interactive tool, DAFO users can "try on" various transfer patterns, ribbon trims, and strap and padding colors. The Creation Station's straightforward design is easy to use and works equally well on desktops, tablets, and smart phones. Favorite designs can be saved, printed, and shared via email, text, and social media. Steering patients to the Creation Station prior to an appointment can save the practitioner valuable clinic time and improve patient compliance.

Cascade DAFO
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Össur Rebound PCL Brace

New from Össur is the Rebound PCL, a dynamic force brace for rehabilitating posterior cruciate ligament (PCL) ruptures. The Rebound PCL is designed to stabilize the knee while providing appropriate levels of physiologic loading force during both knee extension and knee flexion, replicating the functional mechanics of the native PCL. It applies an anterior force on the posterior proximal tibia to counteract posterior translation, which helps improve posterior knee laxity following PCL injury. The Rebound PCL brace can be used in patients with acute PCL tears and for graft protection following PCL reconstruction.

Össur
800/233-6263
ossur.com

Spinal Solutions EZ-APO

Spinal Solutions announces the availability of the EZ-APO (Atlanta Prosthetics & Orthotics) ankle foot orthosis (AFO). The EZ-APO device is ergonomically designed to optimize fit around the footpad and malleolus and provide tibial tuberosity relief. The AFO is made entirely of pre-preg carbon fiber, which allows for strength and flexibility without adding weight, and is structurally reinforced in high-stress areas. Made in the US, it is available as custom-to-cast, custom-to-measure, or in prefabricated sizes XS-L with a right or left orientation. Introductory pricing includes 50% off the first device ordered.

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market mechanics

By Emily Delzell

Implant sales rise in developing markets

While the hip and knee reconstruction market struggles to generate significant growth in Europe and the US, the implants are increasingly being commoditized in countries with developing economies such as Brazil, India, and China, and driving their respective markets at a rapid pace, according to an August 25 report from London, UK-based research and consulting firm GlobalData.

The company's report states the booming populations of Brazil, India, and China have a growing middle class that can afford a new quality of healthcare, and they are also gaining access to increased reimbursement.

As more training sessions take place in countries like China, where surgeons tend to devote more time to training compared with the US, there is promise for greater future adoption of techniques and products, said Linda Tian, MSc, GlobalData's managing analyst covering medical devices. Tian also noted emerging economies are entering the US market with Food and Drug Administration-approved implants, with companies such as Taiwan-based United Orthopedics attempting to sell them at lower prices than those of products already on the market.

Multinational corporations have historically accounted for most of the market in these emerging countries, but now more than 30% of the market is held by domestic manufacturers, a change that has forced multinationals to rethink the value for the price of their products and to reassess their strategy for sustainability, said Tian. ler

Exhibit examines arts-protheses link

A major exhibit at the Henry Moore Institute in Leeds, UK, explores the relationship between visual arts and prostheses.

"The Body Extended: Sculpture and Prosthetics" traces how artists have addressed radical changes to the human body.

Presenting more 70 artworks, objects, and images spanning the late-19th century to the present, the exhibition explores how sculpture and medical science have augmented the analog human figure, expanding its reach and power, according to the institute.

The exhibit opened in July and is on view until October 23. Go to henry-moore.org for more information. ler

Mueller outfits top UK soccer team

Prairie du Sac, WI-based Mueller Sports Medicine announced in August that it is now an official team supplier of the UK's Leicester City Football Club, defending Premier League champions.

Mueller, which offers braces, supports, and other products, will work closely with team physiotherapists to provide them with sports medicine products for player injury prevention and recovery. ler

Swiss Sigvaris Group acquires BiaCare

Winterthur, Switzerland-based Sigvaris Group announced in late August that the graduated compression company has completed its acquisition of BiaCare, headquartered in Holland, MI.

BiaCare brings Sigvaris an assortment of compression products designed to treat lymphedema, lipedema, and chronic venous insufficiency, including the Chipsleeve and Compreflex. The acquisition strengthens Sigvaris's North American and global market positions, according to a company release. ler

Rishwain is Vionic global biz president

San Rafael, CA-based Vionic on August 15 reported that Connie X. Rishwain, former president of Goleta, CA-based Ugg, has joined Vionic as president of its global business.

Rishwain will oversee product, marketing, and sales at Vionic and sit on its Board of Directors. She will report directly to CEO Chris Gallagher, who will continue to lead the company's vision and culture.

During her time at Ugg, Rishwain led the company's growth from a $10 million niche surf brand to a $1.5 billion global lifestyle brand. Previously, she held senior roles at Deckers (Ugg, Teva, and Simple brands), Impo International, and the Nine West Group. Rishwain also sits on the board of KIDS. (Kids in Distressed Situations) – Fashion Delivers, and was recently elected to the Board of Regents of the University of the Pacific in Stockton, CA. ler

AOPA honors Watson for O&P lifework

The Washington, DC-based American Orthotic & Prosthetic Association (AOPA) honored Thomas Watson, CP, with its Lifetime Achievement Award at the 2016 AOPA National Assembly, held September 8-11 in Boston, MA.

"The Lifetime Achievement Award is the highest honor in the O&P profession, and Tom Watson was a natural choice. He has run a successful business, while serving his community through his civic engagement. His many years of effective advocacy for the O&P community should be appreciated by all of us," said AOPA president James Campbell, PhD, CO, FAAOP.

Watson and his wife Barbara own Tom Watson's Prosthetic & Orthotic Lab, which has locations in Owensboro and Evansville, KY. He is a past president of AOPA and has served on its Government Relations Committee. He works with the AOPA Veteran's Affairs committee, the O&P political action committee, and is a grass-roots lobbyist who participates in the annual AOPA Policy Forum and educates local lawmakers on O&P year round. ler

ASB schedules 2017 biomechanics event

The American Society of Biomechanics has begun plans for National Biomechanics Day (NBD) 2017, scheduled for April 6.

This year's event, held in April, saw more than 2000 high school students and teachers attending biomechanics demonstrations across the US.

The goals of the annual event are to increase awareness of biomechanics among high school students and teachers and to support the incorporation of biomechanics into high school curricula. Go to nationalbiomechanicsday.asbweb.org for more information. ler

Footwear thesis wins brevity-based award

The University of South Australia in Adelaide announced in August that PhD candidate Joel Fuller won its 3MT (Three Minute Thesis) competition for his work exploring the link between trendy minimalist athletic shoes and injury.

Fuller was one of eight candidates presenting their work in the competition, designed to help future scientists learn to communicate better with the public.

He will advance to compete against a larger field at the September 30 Asia-Pacific 3MT competition, open to candidates from Australia, New Zealand, and some parts of Asia, at the University of Queensland in Brisbane. ler

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Data detail ConforMis implant benefits

Results from two clinical studies presented at the International Congress for Joint Reconstruction Pan Pacific Orthopaedic Congress, held August 10-13 in Gainesville, FL, show the iTotal CR customized knee replacement made by Bedford, MA-based ConforMis provides superior patient outcomes and has the potential to lower per-episode-of-care costs compared with traditional off-the-shelf (OTS) implants.

In an independent prospective investigator-initiated study of 62 total knee replacements, those who received an iTotal CR had a significantly shorter length of stay (1.6 days vs 2.7 days) and were more likely to be discharged home (97% vs 80%) compared with OTS patients. Further, a significantly higher proportion of iTotal CR patients were able to achieve range of motion greater than or equal to 120˚ (84% vs 45%) at the time of discharge.

Based on these results and published economic data, investigators concluded the ConforMis implant has the potential to save hospitals approximately $2200 per patient.

In a separate multicenter prospective study of 740 patients, iTotal CR patients had significantly better functional outcomes—including walking, rising from a chair, and walking faster up and down stairs—compared with patients who received an OTS implant. ler

Coral scores 100% in surprise FDA audit

Mineral supplement seller Coral reported in August that the Food and Drug Administration (FDA) gave the company a perfect score in a surprise audit.

The FDA came to Coral's Carson City, NV, facility in May to inspect contract manufacturing, receiving, holding, and distribution of dietary supplements and review Coral's written procedures and related records for the holding, distribution, and labeling of dietary supplements. The FDA observed no deficiencies.

Coral is an own-label distributor of bulk calcium carbonate, toothpaste, and finished dietary supplements, ranging from coral calcium to molecular hydrogen. ler

OPAF hosts First Swing at NAGA event

The Charlotte, NC-based Orthotics & Prosthetics Activities Foundation (OPAF) on August 15 hosted a full-day First Swing Learn to Golf Training and Clinic as the kickoff event of the National Amputee Golf Association (NAGA) Championships at Pumpkin Ridge Golf Club in North Plains, OR.

First Swing Instructors WC Fields and Bob Tipton, PT, led the training.

More than a dozen participants took part in the morning training session that included classroom and driving range work. In the afternoon attendees had a chance to practice their new skills on the course. ler

Cascade Dafo offers virtual decoration

Cascade DAFO reported in August that its DAFO Creation Station, an online interactive tool for choosing colors and patterns for the Ferndale, WA-based company's custom DAFOs (dynamic ankle foot orthoses) is available at cascadedafo.com.

Patients can use the tool to apply various transfer patterns, ribbon trims, and strap and padding colors to a virtual custom DAFO.

Steering patients to the Creation Station before appointments can save practitioners valuable clinic time, according to a company release. ler

Athletes undergo Quest biomarker tests

Virginia Polytechnic Institute and State University in Blacksburg reported in August that it plans to use Madison, NJ-based Quest Diagnostics' blood testing service to look for associations between biomarkers and biomechanics, training, recovery, and other variables relevant to sports injury risk in some of its athletes.

Blood samples from players on the university's men's football and women's soccer team will be tested with Blueprint for Athletes, Quest's suite of laboratory blood tests that gives amateur and professional athletes data to help improve performance and lower injury risk.

Currently, participating players are being tested throughout the 2016-2017 competitive seasons for biomarkers such as vitamin D, creatine kinase, and glucose; players, coaches, and athletic staff are using this feedback to adjust nutrition and other aspects of training.

Quest and Virginia Tech plan to expand the collaboration to look at associations between biomarkers and biomechanics, as well as gender-specific responses to training and injury recovery, under the direction of Robin Queen, PhD, associate professor of biomedical engineering and mechanics and director of the Kevin P. Granata Biomechanics Lab at Virginia Tech. ler

Ability, Freedom Innovations join for study

Exton, PA-based Ability Prosthetics and Orthotics and Freedom Innovations, headquartered in Irvine, CA, in September reported they are collaborating on a study comparing Freedom's new Kinnex Microprocessor Ankle with a typical carbon fiber prosthetic ankle.

The study will include 30 patients who will complete three research visits involving standardized surveys, functional tests, and 2D motion analysis to measure the systems' impact on mobility, balance, comfort, and walking on sloped surfaces.

Ability is recruiting patients. Visit abilitypo.com/research or contact Brian Kaluf, BSE, CP, Ability clinical outcome and research director, at brian.kaluf@abilitypo.com for more information. ler

Chaco brings Tread Labs to retailers

Stoneham, MA-based Chaco's founder and original designer of its sandals, Mark Paigen, announced on August 18 the wholesale launch of Tread Labs, a new line of orthotic insoles. The insoles' features include four arch heights in sizes for men and women, easily replaceable Velcro top covers, and a lifetime guarantee.

Paigen developed Tread Labs insoles and started selling them online in 2015 to get direct consumer feedback before offering the line to retailers. Tread Labs is now ready for wholesale business, he said. Margins start at 60%, and the company offers a starter program to outfit new retailers with a demo fleet of insoles for easy customer try-ons. ler

OPIE launches Amplitude resource guide

Gainesville, FL-based OPIE Software announced in August that Amplitude Media Group, headquartered in Northglenn, CO, is an integrated supplier. With this partnership, Amplitude Media's *Limb Loss Resource Guide (LLRG)* can now be purchased digitally through the OPIE Software platform.

Key features of this integration with Amplitude Media include online order submission and the ability to customize the *LLRG* with practice logos and contact information. ler

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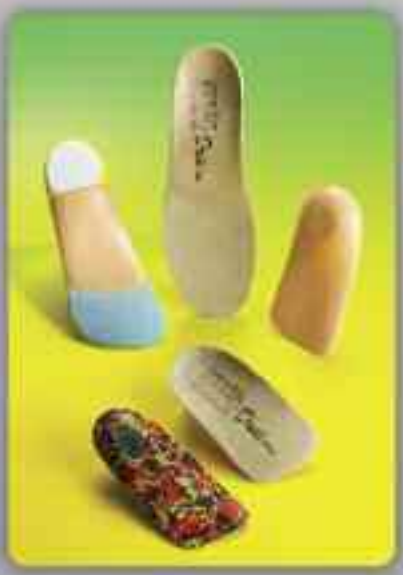

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